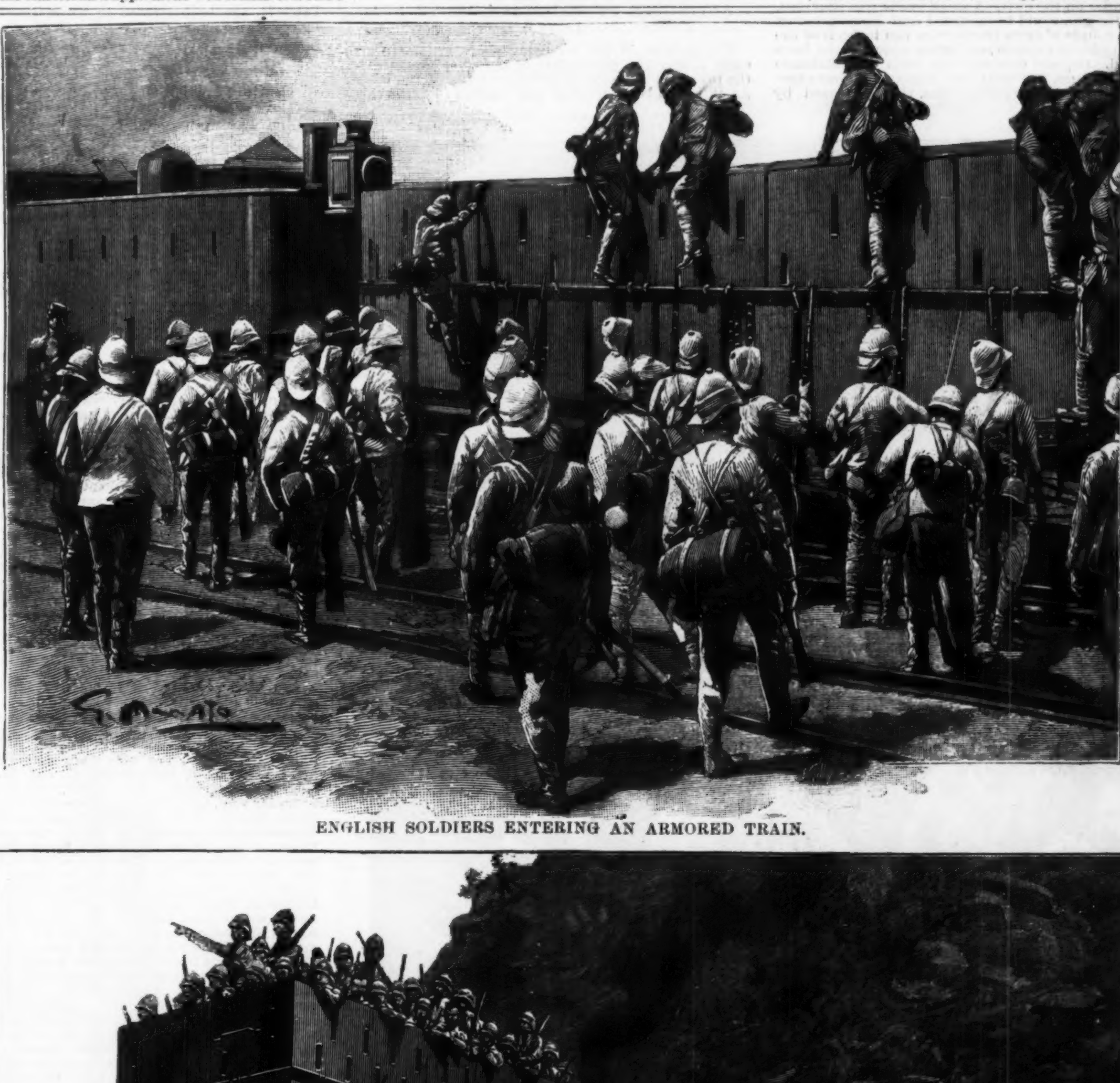
SCIENTIFIC AMERICAN SUPPLEMENT. No. 1255

Scientific American, established 1845.
Scientific American Supplement, Vol. XLIX. No. 1255.

NEW YORK, JANUARY 20, 1900.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



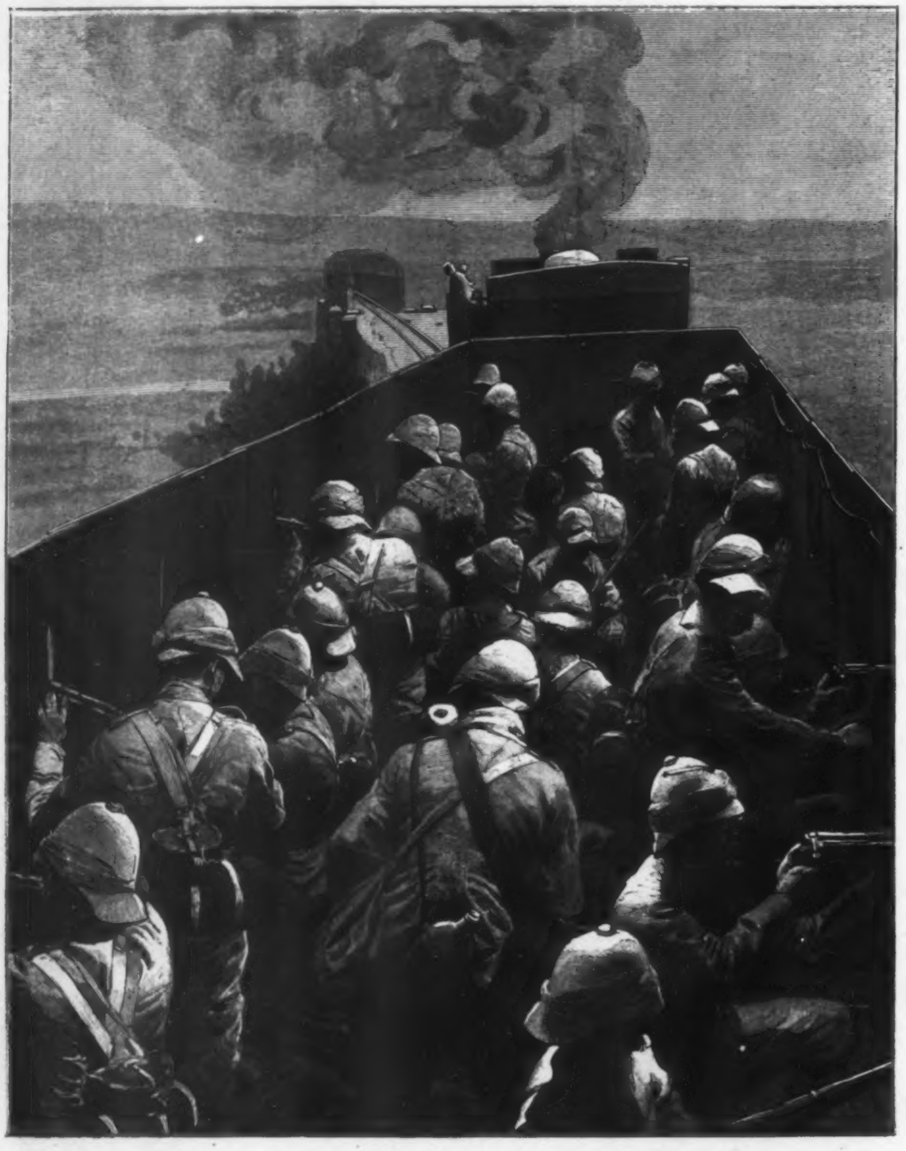
ENGLISH SOLDIERS ENTERING AN ARMORED TRAIN.

ARMORED TRAIN MAKING A RECONNAISSANCE.

ARMORED TRAINS IN SOUTH AFRICA.

IT is probable that in the Franco-Prussian war protected trains and locomotives were used for the first time on the field of battle, and in the various sorties from Paris the French troops were frequently assisted by the fire of light field pieces carried on cars. When the Communists were holding the capital against the regular troops at Versailles, an armed train operated on the railroad in the direction of the Château Breçon, and the Communists succeeded in silencing the batteries which the regulars were endeavoring to establish in that position. Probably the first regular armorclad train was that used during the first stages of the campaign against Arabi. It was built at Alexandria by a party of blue jackets and was composed of a locomotive and a number of trucks protected by iron rails, iron plates and sandbags. The engine was placed in the middle of the train, while a Nordenfeldt machine gun was mounted on the leading protected truck and a 4-pounder on the next. A small crane was provided, so that the gun could be mounted and dismounted at will. A couple of extra trucks were run in front of the train in order to explode any mines which might have been laid. On one occasion this train did admirable service. France, Germany and England all have specially constructed armored trains, that possessed by the First Sussex Artillery Volunteers of England being perhaps the most complete train of its kind in the world, the truck being specially constructed for the gun, which is mounted on an ordinary field carriage which rests on a turntable pivoted in the center, so that it can be turned in any direction.

Armored trains mounting field pieces and machine guns have been used quite extensively in South Africa by the British forces. Sometimes the result has been successful, and sometimes the contrary was the case. The train shown in our engraving consists of a powerful engine, tender and three trucks. The sides are raised to over 6 feet in height, the plates being loopholed with longitudinal slots through which shots may be fired. The train was painted khaki color, and each truck is capable of carrying 64 men. The driver and fireman are completely closed in and take their directions by bell signals. The armored train was found very useful in protecting engineers in repairing breaks in the road. On one occasion a captive balloon was attached to the train; this was at the action at Farquhar's Farm on October 30. A searchlight was also mounted on the truck and proved very useful on a number of occasions. The railway at Mafeking was patroled for some time by an armed train fitted with Nordenfeldt and Maxim quick-firing machine guns. An acetylene search light was also used. The engine was placed between two flat cars, each of which was 30 feet long, mounted on four pairs of wheels, and was capable of holding sixty men. The entire train was covered with ⅜-inch steel armor plate over double iron rails. At some recent trials it was found that the shots from Mauser rifles penetrated even this armor at 200 yards range. On November 15, an armored train was attacked by the Boers near Ladysmith. The train was thrown from the line and several of the men, among them Winston Churchill, were taken prisoners. It will also be remembered that Major-General French managed to get out of Ladysmith by the last train, which was an armored train, but not as powerful as that shown in our engraving. Four miles from Colenso the train was fired upon by the Boers, but none of the passengers were hit.—For our engravings we are indebted to L'Illustration.



ENGLISH SOLDIERS FIGHTING FROM AN ARMORED TRAIN.

ALTITUDES OF RAILWAYS ABOVE SEA-LEVEL.

WE propose in the following short article to give some interesting particulars of altitudes attained by the principal railways in different parts of the world. As it would be tedious to our readers to place these details before them in the body of the text, we shall give them in a tabular form, which will enable them to be the more readily compared and appreciated. It might be supposed that the rack railways would head the list, but though they run the others very closely, it will be seen from Table II. that they do not quite bear away the palm. There are three lines which may be referred to independently of those scheduled in the tables, as they are laid out partly on the rack and partly on the ordinary steam traction system. These comprise the lines between Beyrouth and Damas, and between Eisenery and Vordenberg. They are both in Syria, and attain each an altitude 3,960 feet above the same datum. The state railway from Herzegovina to Bosnia, belonging to the same system, reaches to a height of 2,904 feet above sea level. It will be advisable to tabulate the other lines, which are ordinary locomotive railways, under two heads, viz., those which belong to Europe and those which are situated in foreign countries.

TABLE I.—RACK RAILWAYS.

Name of Railway.	Maximum altitudes in feet above sea-level.
Pike's Peak, U. S.	13,200
Görner Grat	10,065
Jungfrau	7,613
Rothorn	7,425
Pilate	6,850
Rigi	5,578
Monte Generoso	5,280
Gaisberg	4,243
Semmering	2,912

TABLE II.—EUROPEAN RAILWAYS.

Name of Railway.	Maximum altitudes in feet above sea-level.
Land-quart to Davos	5,390
Kaitlad to Scheidegg	5,201
Brenner	4,494
Guadarrama, Spain	4,488
Mont Cenis	4,290
Lioran, France	3,800
St. Gothard	3,811
Alais to Brionde, France	3,395

It should be mentioned that the first two lines in Table II. are both located in Switzerland, and have a gage of one meter.

TABLE III.—RAILWAYS IN FOREIGN COUNTRIES.

Name of Railway.	Maximum altitudes in feet above sea-level.
Central Peruvian	14,555
Chilean and Bolivian	13,000
Denver and Rio Grande	11,385
Vera Cruz	9,042
Union Pacific	8,292
Canadian Pacific	5,940
Northern Pacific	5,610

The highest altitude to which a cable line has attained is that of one near Stanserhorn, which rises to 6,100 feet. It will be observed that with the exception of the Pike's Peak rack railway, the lines which traverse the passes of the Andes, in South America, can give the others a wide berth, although some of them can boast of very respectable figures.—The Engineer.

JAPANESE PAPER.

THE peculiar qualities of Japanese paper, most of them excellent ones, and the great variety of uses to which it is applied, are known everywhere. It is a wood or bark paper, and derives its properties from the substances of which it is made and the method of its manufacture. Several plants are cultivated for the manufacture, which, in the absence of English names, must be called by their Japanese or scientific ones, of which the principal are "mitsumata" (Edgeworthia papyrifera), the "sozo" (Brossonia papyrifera), and the "gampiju" (Wiekstroannia canecensis). Bamboo bark also furnishes a good paper, but is not much used. The mitsumata ramifies into three branches, and is cultivated in plantations, being propagated from seeds and by cuttings. It is fit for use in the second year if the soil is good. Its cultivation and exportation have reached an enormous importance, largely because the Imperial Printing Office uses it for bank notes and official documents. The sozo is propagated by seeds, and somewhat resembles the mulberry. The gampiju is a small shrub which is cut in its third year. To make paper, the bark is steeped in a kettle with buckwheat ashes to extract the resin in it. When it is reduced to a pulp, a sieve-bottomed frame with silk or hempen threads is plunged within, very much as in Western paper-making. This, letting out the water, holds the pulp, which, felting, is to form the future sheet of paper. This is pressed, to squeeze all the water out, and is left to dry. The uses made of paper in Japan are innumerable, particularly in old Japan, which treasures up its past. The papers, though all made in a similar way, are called by different names, according to the uses to which they are applied and their origin. Window lights are made of paper, and partitions between rooms, when it is stretched on frames, which work as sliding doors. The celebrated lanterns called gifu are made of it at Tokio and Osaka. Under the name of shibuganni it is applied to the covering of umbrellas which are sold in China and Korea. As zedogawa-shi bank notes are printed on it. Oiled, it is kappa, impermeable and suitable for covering packages and for making waterproof garments. Handkerchiefs are made from it, cords by twisting. For light, solid articles it is mixed and compressed very much as our papier-maché. Covered with thick paste and pounded, it forms tapestries. Imitations of Cordova leather are made of it by spreading it and pressing it with hard brushes upon boards in which suitable designs have been cut. It is then covered with oil and varnish. Japan produced nearly five million dollars' worth of paper in 1892. Unfortunately, European methods of manufacture have been introduced, and there is danger of the paper losing its distinctive qualities.—Popular Science Monthly.

THE GERMAN BEER INDUSTRY.

THE German beer industry has grown year by year, and the increasing capacity of the establishments has made it necessary for the brewers to search for new markets where their overproduction could be disposed of. In the year 1885, the export of German beer reached its maximum, amounting in that year to 1,318,000 hectoliters (28,996,000 gallons), representing a value of 24,000,000 marks (£1,200,000). The next year, however, showed a decrease, and since then the export has gone down to about one-half of what it was in 1885. According to the United States consul at Kehl, the reason given for this decline is that the countries which were Germany's best customers—France, Belgium, and the Netherlands—have increased their output sufficiently to nearly meet the home demand. The high duty placed on foreign beers by France has also had the effect of considerably reducing the import of German beers into that country. In all those years the export of German beer in bulk (barrels) has been greater, contrary to general belief, than in bottles. German beer once had nearly a monopoly of the beer trade of South America, but there also, it is stated, the demand has decreased, while at the same time, according to trade reports, the demand for the United States has increased. The decline of the German beer trade in Brazil alone, during the years 1896 and 1897, is given as amounting to fully three-fourths of what the German brewers had exported to that

country in former years. It is a noticeable fact that while the export has declined year by year, the production of beer in Germany has advanced steadily, showing that the home consumption has greatly increased. At present, the United States is the best foreign customer for German beer, importing in 1895 522,138 gallons; and in 1896, 689,456 gallons. The export of beer from Germany to Venezuela, Japan, and China together did not in the years given amount to one-half the exports to the United States alone. Brazil and British India, as consumers of German beer, come next to the United States. The German brewing industry has strong hopes of entirely supplanting the English in Australia and other British colonies.—Journal of the Society of Arts.

[Continued from SUPPLEMENT, No. 1254, page 20109.]

CYCLE CONSTRUCTION AND DESIGN.*

By ARCHIBALD SHARP, A.M. Inst. C.E.

Dust-proof and Oil-retaining Bearings.—In comparing the two figures showing outward-cups and inward-cups bearings respectively, it will be noticed that if oil be supplied to the middle, it will be retained in the inward-cups bearing. The inward-cups bearing is therefore oil-retaining. The best cone-adjusting hubs are at present made with down-turned lips, so that they are made slightly oil-retaining. Dust-proof washers are often supplied, which completely block up the space between the cup and the cone.

Fig. 12 is a view, partly in section, of the Centaur cup-adjusting pedal.

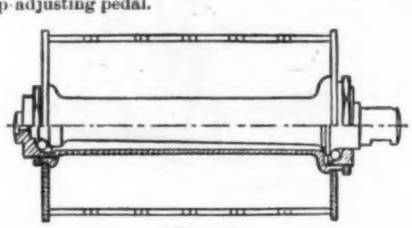


FIG. 12.

Fig. 13 is a view of outward-cups crank-angle bearings used in the Rudge-Whitworth bicycle. The latter is cone-adjusting, the former cup-adjusting. In the Rambler bicycle, one of the cranks is forged in one piece with the axle. The other crank is cottered,

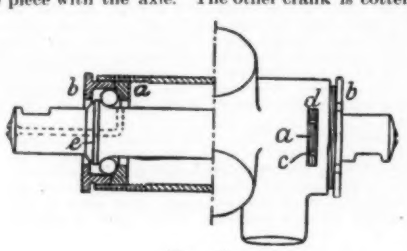


FIG. 13.

and has three claws projecting from its boss to carry the chain-wheel. Fig. 14 is a section of the B.S.A. ball-head, a special feature of which is the spherical seatings for the ball-races.

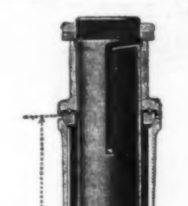


FIG. 14.

Fig. 15 is a section of the Quick Detachment hub, in which the cones are formed on a hollow spindle; the inner spindle fastening the hub to the frame can be withdrawn without disturbing the adjustment of the bearing, and the wheel can be easily removed from the machine.

FIG. 15.

Wheels.—Most carriage and vehicle wheels are made with wooden spokes uniting the hub to the rim; the rim is made of segments of wood, and the whole construction is secured by an iron tire shrunk on the wood rim. An initial compression is thus induced on the spokes, which is balanced by a circumferential tension on the combined rim and tire. In bicycle wheels the stress conditions are reversed; the spokes are made of thin wire incapable of resisting compression. They are screwed up until a certain tension is obtained, which induces a circumferential compression on the rim. Direct spokes run radially from the hub center to the rim. A direct-spoke wheel is quite satisfactory for the purpose of transmitting the load from the axle to the ground. But for driving, the direct-spoke wheel may not be rigid enough tangentially. If a driving effort be applied to the hub of a direct-spoke wheel, the hub rotates and the rim lags behind, until the center-lines of the spokes all become tangential to a very small circle. The driving moment applied to the wheel must be equal to the product of the total pull on all the spokes multiplied by the radius of this small circle.

In a tangent-spoke wheel the spokes are arranged tangentially to a circle of considerable size as compared with the aforementioned one; and if the initial pull on the spokes be the same for all, one-half are pulling at the rim, tending to drive it forward, the other half tend to drive it back. The driving effort is transmitted by the pull on one set of spokes being slightly increased, that on the other set slightly decreased. For a given driving moment the stress on the spokes may be very much less than in the direct-spoke wheel.

Spread of Spokes.—If the spokes of a tension-wheel all lay in the same plane, the wheel would have very little lateral rigidity; any couple tending to move the spindle would distort the wheel. When the spokes are spread out at the hub, a bending-moment applied at the spindle would have the effect of increasing the pull on one pair of opposite spokes, and diminishing the tension on the other pair.

Rims.—The lateral spreading of the spokes of a wheel should be looked upon as a means of connecting the hub rigidly to the rim, rather than of giving the rim lateral stability relative to the hub. The rim must be of a form possessing sufficient lateral stability in itself, otherwise it cannot be built up into a good wheel. The lateral components of the pulls of the spokes tend to bend the rim sideways. If the rim be very narrow, as was the case with the solid tires of the past decade, the liability of the rim to buckle is greater than with the wider rims used for pneumatic tires.

Wood Rims.—The question of wood versus steel for wheel rims is one that is not clearly understood, even by many engineers; but the mechanical principles involved are very simple. The strength of a rectangular beam subjected to bending is proportional to its width, the square of its depth, and to a coefficient depending on the strength of the material. The width of the rim for a pneumatic tire must be practically the same whether wood or steel be used. I have here two beams of wood and steel respectively of equal width, length, and weight. It will be noticed that the steel beam is hardly strong enough to support its own weight, whereas the wooden beam is much stronger and stiffer. Roughly, the strength of steel may be taken 10 times that of wood. But the weight of steel is 10 times that of wood, and consequently, if the two beams be of the same weight, the wood beam is about 10 times as deep as the steel beam. So that, due to the increased depth, the strength of the wood beam is 100 times that of the steel beam, but, due to the smaller strength of the material, its strength coefficient is only one-tenth; the final result being that the wooden beam is about 10 times the strength of the steel beam of the same width and weight. Of course, no bicycle rim is exactly rectangular in section, and by curving the section, the strength of the steel rim is increased; so that comparing actual bicycle rims of steel and wood, the difference in strength may not be nearly so great as the above figures (for rectangular sections) show.

Materials.—To deal thoroughly with the subject, "Materials of Cycle Construction," would require a separate course of lectures. I can only refer briefly to the strength of some of the more important materials. If a load be applied at the end of a bar, and be gradually increased, the bar will ultimately break. If the bar be of one square inch section, the load on it at the instant of breaking is called the breaking tensile strength of the material. The effect of small loads on a bar is to distort its shape; if the stress applied does not exceed a certain amount, the bar recovers its original shape when the stress is removed. The elastic strength of a material is this limiting stress, and of course in any structure intended to last for a considerable time it should never be exceeded. If the elastic strength be exceeded, the deformation is more or less permanent, and the period of ductility or plasticity is reached. Now, steels of strength varying from 25 to 75 tons per square inch are used by engineers every day. Steel rails have an average strength of about 50 tons per square inch; the steel used in steam boilers, or for large bridges, has a strength of 26 to 30 tons per square inch. The question at once arises—why is the strongest steel not always used? This question can be better answered after having discussed the amount of mechanical work done in loading a bar. In loading a bar up to its elastic limit, the bar stretches slightly, and the applied load moves through a certain distance. The work done is a measure of the resiliency. The chief function of springs is the absorbing or storing up of a certain amount of energy or mechanical work, and restoring it again. When the elastic limit is exceeded, the stretch of the bar is much greater, and the amount of work required to actually break it is considerable. The relation between the stress, the deformation, and the work done on a bar can be best represented by a stress-strain diagram. In Fig. 16 the stress on a bar at any instant is represented by the vertical ordinates, and the corresponding elongation by the corresponding abscissæ. Confining our attention to the stress-strain diagram for mild steel, curve A, as the load is gradually increased from zero up to about 30,000 lb. per square inch, the elastic extension of the bar is proportional to the load. The total elastic extension, however, is so small (about 1-100th of an inch in a bar 10 inches long) that this portion of the stress-strain diagram practically coincides with the vertical axis. On further increasing the load, the elongation takes place at a quicker rate, until when the stress indicated by the point *b* is reached, the material yields suddenly a considerable distance without any increase of applied stress. This goes on until the point *c* is reached, when to produce further elongation, a further increased stress is required. The relation between stress and strain is then indicated by the line *c d e*, *e* indicating the breaking point of the material, giving an elongation of about 25 per cent. of the original length of the bar. The work done in breaking the bar is indicated by the area between the base line of the diagram, the stress-strain curve and its ordinates, and may be said to be a measure of the toughness of a material. In a material like hard tempered steel there would be little or no elongation before fracture; and although its strength might be very great, its stress-strain diagram would be a line lying very close to the vertical axis, the work done in breaking it would be

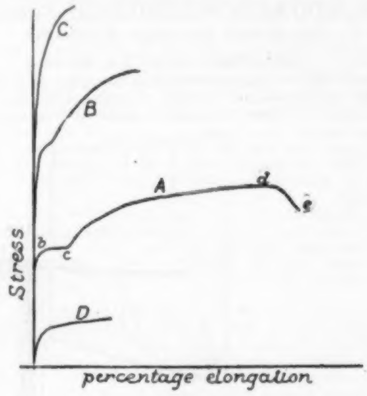


FIG. 16.

very little, and a slight concussion might be sufficient for fracture. Curve B shows the stress-strain diagram for a solid-drawn steel tube. Curve C that for the helical tube used by the Premier Cycle Company; this has a high tenacity, and a comparatively large amount of work is required to break it; it is therefore a very suitable material for cycle frames. Nickel steel has a very high tenacity, and a fair amount of elongation before fracture. Aluminium-bronze contains a very small proportion of aluminium, and is therefore a heavy alloy. Alloys containing a large percentage of aluminium, and therefore light, have very low strength. Curve D shows the stress-strain curve of pure aluminium; a glance at the various curves will show that aluminium is utterly unsuitable for use in a cycle frame.

Malleable cast iron is used by our best bicycle makers for the lugs of the frame. Ordinary cast iron is a material utterly unsuited for use in a cycle frame; but by a process of cementation in furnaces extending over a period of 7 to 14 days, the castings are converted, by the removal of the contained carbon, into malleable iron, a material having quite different physical properties. The malleability can easily be demonstrated by smashing under a hammer. Makers interested in steel stampings or sheet steel lugs sometimes try to throw discredit on malleable cast iron lugs, but if properly made they answer their purpose admirably, even if they are a trifle heavier than sheet steel lugs.

* Lecture delivered before the London Society of Arts and published in the Journal of the Society.

ORIGIN OF THE WORD "PHYSICIAN."

AT the meeting of the General Medical Council, December 2, Mr. Brudenell Carter read the following extract, bearing on the origin of the word "physician," from a letter written by Dr. Murray, the editor of the Oxford Dictionary:

Dr. Murray said: "The word was taken by us from Norman French in the thirteenth century in the form *fisicien* and in its present sense of practiser of the healing art, medicus; the only sense which it had in contemporary French. It has never had any other sense in English, though one or two writers have expressed a desire to abolish this and to convert the word back to the sense of Latin *physicus*, Greek φυσικός, student of nature, naturalist, natural philosopher. Hume did this, but only as an etymological fancy. In French it has been different; *medecin* has successfully ousted *physicien*, and the latter in modern French since the sixteenth century has meant physicist. If you will turn to DuCange's Lexicon of Mediæval Latin, you will find that the regular mediæval Latin sense of *physica* is medicine, and *physicus* equals *medicus*. But in classical Latin and as late as the Latin lexicons come down, *i. e.*, to the fifth century or so, *physica* in Latin literature meant natural science and *physicus* a physicist. What you have to do, then, is to show how Latin *physicus* and *physica* passed between the fourth or fifth and say the eighth or ninth centuries, during the very midnight of the middle ages, from the ancient to the mediæval and modern sense. This is an inquiry that lies far away behind the scope of an English or even a French dictionary; it is part of the general history of the Latin language during the period of the break-up of the Roman empire and civilization, for which perhaps no materials exist, and all that can be said is that the change took place and was a very natural and intelligent one. I have little doubt that even in the third century the common peasant of Italy or Gaul thought a *physicus* must know something about the influence of stars and planets and mysterious influentias or influenzas generally and about the position of bones and virtues of herbs, the only practical use of *physica* to him, and so thinking the *physicien* a *medicus* called the *medicus* a *physicus*. Does not the ignorant nineteenth-century Englishman call a drug-seller a chemist for the same reason, and does not the drug-seller find it profitable to call himself a chemist, which he is much less than a baker or a whisky maker is? Well, when the Roman civilization perished, all the literary class (as a class) perished and the peasant survived, and his Latin became the language of the modern world. He did not call in a *medicus* to use his *medicina* to cure his bad *crures* or his aching *caput*, but got a *physicus* with his *physica* (*fisicus* and *fisica* he wrote them when he could write) to attend

to his *gampas* (pins or hockey-sticks) or his *testa* (shell or cocoanut). The substitution of *physicus* for *medicus* is then only part of the great revolution; but it lies a long way anterior to English and to the Englishmen of the thirteenth century who accepted *physicien* or *fisicien* as quite the fashionable courtly learned title for their own leche or leech. Of course, modern etymologists, going back to the original Latin and Greek sense, are apt to think the words ought to have the original sense, which is to undo history, and pull down the Tower, St. Paul's, and Westminster, to say nothing of Cannon Street Station, in order to restore Roman London. (They do so at Athens and Rome.)"

[Continued from SUPPLEMENT, No. 1254, page 20109.]

THE HOMEMADE WINDMILLS OF NEBRASKA.

By ERWIN HINCKLEY BARBOUR.*

THE MERRY-GO-ROUND MILLS.

IN the Merry-go-round mill is found another attempt at the construction of mills of unlimited size. However, some of these mills have natural limitations, especially those mounted upon towers. Such mills are of rather complex construction, and are not put up by the farmer, but by a carpenter, and at considerable expense. Mounted as they are upon towers, like the Turbine mill of the shop, they can soon reach a size where the wind can upset them, however well anchored. This has led to the towerless Turbines, which stand low upon the ground, hence are capable of a greater circumference. In the smaller ones, which we class with the Merry-go-rounds, the shutter-like fans form a sort of revolving cylinder, which revolves about a central axis. The shutters close on one side and so exclude the air, and open upon the other so as to catch the air, and even the amount is easily regulated by an encircling rope, which allows them to open much or little, according to the velocity of the wind.

This form of mill, though useful once, is now antiquated, and has been replaced by cheaper and better forms, so it needs no further mention here. Several are still to be seen in the vicinity of Lincoln, at Grand Island, Greeley Center, and elsewhere.

They often escape notice from the fact that they are mistaken for water tanks mounted upon high towers.

The mounted Merry-go-round, as designed by W. Wynn, of Custer County, consists of a number of fans revolving about a central axis (Fig. 14). About the same axis also revolves a semicircular hood, as the cut will show; thus exposing half of the fans, and shielding the other half. The revolving hood, which seems to be an original as well as a good idea, is easily guided by a large vane. Its construction is simple, its cost small, and it is well adapted to go on the tops of sheds, cribs, and outbuildings, thus doing away with towers. The shield might be lightened somewhat, for it does not seem necessary that it should be a full semicircle; a quadrant or a quarter circle would do just as well, and will weigh less and cost less time and money. Mr.

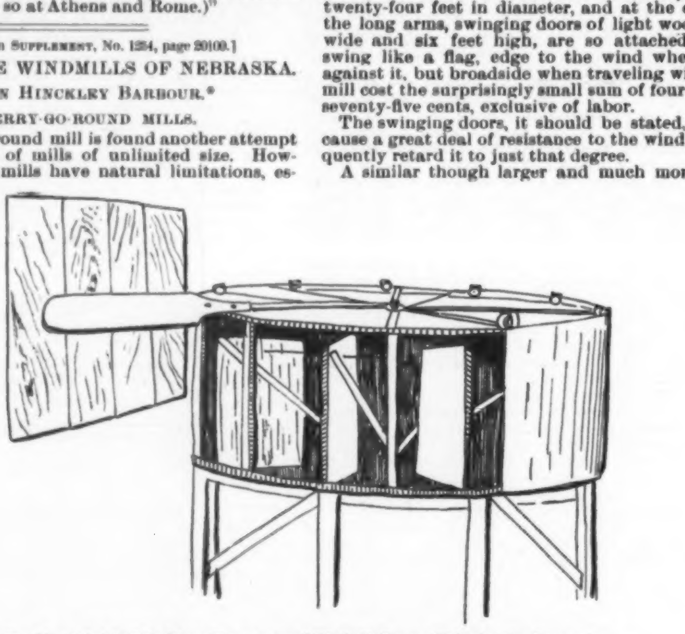


FIG. 14.—A sketch of the Wynn Merry-go-round Windmill, Berwyn, Nebraska, showing revolving hood, which is guided by a rudder so as to protect half of the fans and to expose the other half.

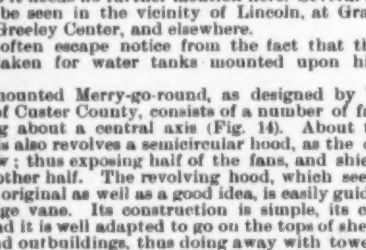


FIG. 15.—Ground plan of a form of Merry-go-round proposed by the writer. Diameter, 20 to 25 feet or more. Each of four posts carries a gate which may be opened and closed to admit or shut out the wind. Each gate is to be so arranged as to turn backward through an angle of 270 degrees, as from position *A* to position *B*.

Wynn's shield runs upon friction rollers. When the mill is to be thrown out of gear, the guard is simply revolved until it covers all the fans on the windward side. Small and medium sized mills might be constructed in this way. For medium and large Merry-go-rounds the writer would propose a design such as is shown in Fig. 15. Here the fans, which may be large or small, as desired, are exposed to the wind on one side, and shielded on the other, by means of gates, as is apparent in the figure. In case of high wind the gates can be partly closed, thus checking the rate of the mill, or they may be closed altogether, thus stopping the mill.

A singular Merry-go-round is reported by Mr. E. E. Blackman, which according to his account, does excellent work. "It irrigates ten acres near the Colorado line," where semi-arid conditions prevail, and where the test is all the more severe. This Merry-go-round is twenty-four feet in diameter, and at the extremity of the long arms, swinging doors of light wood, four feet wide and six feet high, are so attached that they swing like a flag, edge to the wind when traveling against it, but broadside when traveling with it. This mill cost the surprisingly small sum of four dollars and seventy-five cents, exclusive of labor.

The swinging doors, it should be stated, are apt to cause a great deal of resistance to the wind, and consequently retard it to just that degree.

A similar though larger and much more elaborate Merry-go-round is that of S. S. Videtto, on a ridge near Lincoln (Fig. 16). This mill has a diameter of about forty feet, and the fans are twelve to fourteen feet high. The whole structure is carefully designed and well made, solidly braced, and runs upon a circular steel rail. This is an experimental mill, and it is to be hoped that this, or some equally powerful mill, may yet be perfected.

In many of our river valleys water is to be had in unlimited amounts within ten feet of the surface. It is only a question of raising it so that it will flow upon the land. A powerful mill, if such is possible, will aid materially in irrigating in many places where ditches are impossible.

However impracticable and useless many inventions of our farmers may appear to be at times, yet at all times it is apparent that this inventive movement is an attempt to meet a demand, and who dares to say that the sum total of these inventions may not yet lead to the solution of some of our irrigation problems.

Individual work along these diverse lines seems to be worthy of encouragement, rather than discouragement, and when the matter is worked out by practical men, it will doubtless be possible to write with still more enthusiasm concerning the success of the home-made mill.

The cost may be still further lessened by learning to arrange cribs, carriage houses, and outbuildings with respect to the construction of the Merry-go-round, or other types of mills. Thus by lowering their cost, and by raising their efficiency, according as old models are improved upon, we may with reason expect of these mills still greater usefulness.

TURBINES OR OPEN-FACED MILLS.

In the open-faced or Turbine mill we realize a form which is considered to be much in advance of the preceding. Here there are great and varied possibilities, and one can certainly find the mill suited to his needs.

The writer would classify the Turbine mills about as follows, arranging them in the supposed ascending order of their importance: First, Holland mills; second, Battle-ax mills, including those with two, four, six, eight fans, and the Giant Battle-axes; third, Mock Turbines, which so closely resemble the shop-made product as to be scarcely distinguishable at times, and which include the fixed Turbines, the revolving Turbines, with and without rudders, and the giant Turbines; fourth, the reconstructed Turbines, that is, the second-hand or fallen Turbines bought and fixed over. The last and most efficient of all is a fifth division, the shop-made mills, not discussed in this report, which considers instead the home-made mill.

The Turbine represents what is believed to be the highest order of windmills, and other things being equal it is the one to be recommended. They seem to be as easily built as the Jumbo itself, and they require less material, and are capable of a greater variety of modifications. The simpler forms, at least, are easily and cheaply built, and are plainly to be preferred, according to the writer's belief.

THE BATTLE-AX MILL.

The essential part of the Battle-ax mill is its axis, to which arms are attached, and upon the arms are the blades. The whole is mounted upon a tower made of lumber or of poles cut from the place; or it may be mounted directly upon some crib or outbuilding, thus still further simplifying it. The name Battle-ax is not inappropriate, for there is a possible resemblance in the arms and in the blade to the handle and blade of its precursor. The resemblance is still closer when one sees the mill in rapid motion. Then the blades seem to be chopping the air in opposite directions, and the name Battle-ax seems the more applicable.

There is one objection to the Battle-ax, but not a serious one; it is set in a fixed position with its axis north and south, and is inefficient when the wind blows from the east or west. However, that objection is a trifling one, when it is remembered that our winds are nearly constant. There would be a few days when the wind would render the mill inoperative.

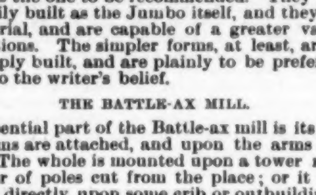


FIG. 17.—The Defender Mill, an eight-fan Battle-ax with canvas sails. Kansas.

The axis, which has already been described as the fundamental part, may be of wood, gas pipe, shafting, or an iron rod, as suits the caprice of the builder. We have seen the axis made of a six or eight foot section cut from a good straight pole, say seven or eight inches in diameter. This was trued up at the ends by a drawing knife, so as to fit and turn easily in its wooden bearings. We have seen eight-inch pieces from the lumber yard treated in the same way.

Again we find them with round iron journals set into the ends of the axes, which doubtless run more smoothly in the wooden bearings. Others are made of iron throughout. In many instances discarded farm machinery with its bearings, cog wheels, etc., are adapted to this purpose. The most ingenious axes which we found were built by taking the axle, hub and all, of an old wagon or buggy, and fastening these to the crude tower. Thus it was an easy matter to secure excellent journals and bearings, for the axle continued to run in the thimble turned to fit it. These were true bearings, and when properly oiled were practically frictionless. The arms were then bolted firmly to the axis, and if necessary were further strengthened by tying them together with twisted fencing wire.

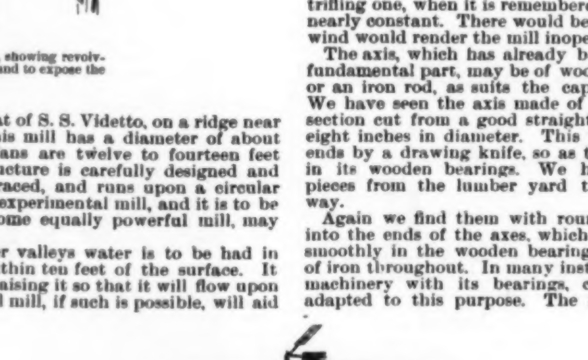


FIG. 16.—A Merry-go-round designed and built by Mr. S. S. Videtto, Lincoln, Nebraska. This is an attempt to design a mill of unlimited size and power. Diameter of mill, 40 to 50 feet; height, 12 to 14 feet. Runs on a circular steel track. Experimental mill.

These mills, which seem to be preferable in most cases to either the Jumbo or the Merry-go-round, vary in size up to those which are a full sixteen feet in diameter. They are subject to a limitation in size, and eighteen to twenty feet approaches the limit, for ordinary purposes at least. Accordingly if still larger mills are desired, one may have to choose the Jumbo or the Merry-go-round.

The ordinary size as seen in daily use raising water for the house, stock, or for irrigation of a small patch, is about eight or ten feet in diameter. The simpler and earlier forms are the more typical, and are well represented by any one of the many Battle-ax mills built by the German farmers around Grand Island.

The Battle-ax is the prevailing form of home-made mill in Central Nebraska.

The average Battle-ax mill has a diameter of about nine or ten feet, some a little less, some more; and from this they run up to the giant Battle-axes, sixteen feet in diameter.

The best examples of such were found on the farm of J. S. Peckham, and on that of his son, E. L. Peckham, some five miles southwest of Gothenburg, in Dawson County. These are wind engines which must surprise anyone who may be at all skeptical as to what may be done with home-made mills.

As we approached this fine farm of one thousand acres, we saw the commodious house, the barns and outbuildings, the timber claim, the young orchard, and a row of six stately windmills which gave a decidedly favorable impression. Four of the mills were shop-

* Condensed from the Bulletin No. 59 of the United States Agricultural Experiment Station of Nebraska, Lincoln, Neb., to which we are indebted for kindly lending the engravings.

made, of various makes, and two were Battle-ax mills of the proprietor's own make.

The two Battle-ax mills stood side by side near the fifteen acre orchard, which they were built to irrigate. Here were growing apples, plums, peaches, small fruits, and grape vines, and yet this is the very region where they say fruit cannot be grown. Had the twin Battle-axes pumped the water into storage reservoirs instead of applying it directly, it would have insured a more even distribution of the water, and even better results. This was the only orchard we saw for miles around.

These twin Battle-axes were made of new lumber, and exceptionally well bolted and braced. The towers were twenty feet high and spread to sixteen feet at the base, the corner posts being four by four yellow pine. The cross braces two by four yellow pine. The axis was eight inches square and sixteen feet long, and the diameter of the mill sixteen feet. Each of the eight arms carried a heavy wooden fan, five and one-half feet long, and five feet at the top, tapering to two and one-half to three feet at the bottom. Thus each of the eight fans exposed nearly twenty-five square feet of surface to the wind. The exercise of economy was not necessary in this case, so a close account of expenses was not kept, but the probable expense was reported at about twenty-five dollars each.

The rate of the wind and the amount of water was measured, giving the following results: Mill No. 1 with two three-inch cylinders and a ten-inch stroke, with one valve in bad order, pumped water from a forty-two foot well at the measured rate of about fifteen thousand gallons in twenty-four hours, in a thirteen and a half mile wind; mill No. 2 had four-inch cylinders and was in better repair, and under the same conditions as No. 1 pumped nearly one thousand gallons per hour. This amount was greatly exceeded when the wind rose later to fifteen miles an hour. If possible, the discharge of both mills will be measured for different wind velocities, and will be reported in a succeeding paper for the benefit of those who may be interested.

About a mile distant on the farm of the son, Mr. E. L. Peckham, was a similar Battle-ax mill, save that it was built with even greater care, and was used similarly to irrigate a garden and a young orchard set out a year or so before. This mill cost seventy-five dollars, including new lumber, two pumps, and all other incidentals.

By striking an average of the cost of these three mills we may judge that the probable cost of such an undertaking will not fall much below forty or fifty dollars where new material is used. In case of stricter economy the cost may fall below twenty-five dollars. There is no reason why the tower should not be built of poles cut from the place, and the axis and arms too for that matter. Then old lumber and boxes make about as good fans as new, and if these items of expense are eliminated, the cost is reduced to the amount necessary for hardware.

This is a commendable pattern of mill, and one which may cost much or little, according to the builder's means.

The remarkable two-fan mill of Elmer Jasperson near Ashland we must class with the Battle-axes (Fig. 20). It is a sort of adjustable Battle-ax, the fans turning upon the short arms to throw it in and out of gear.

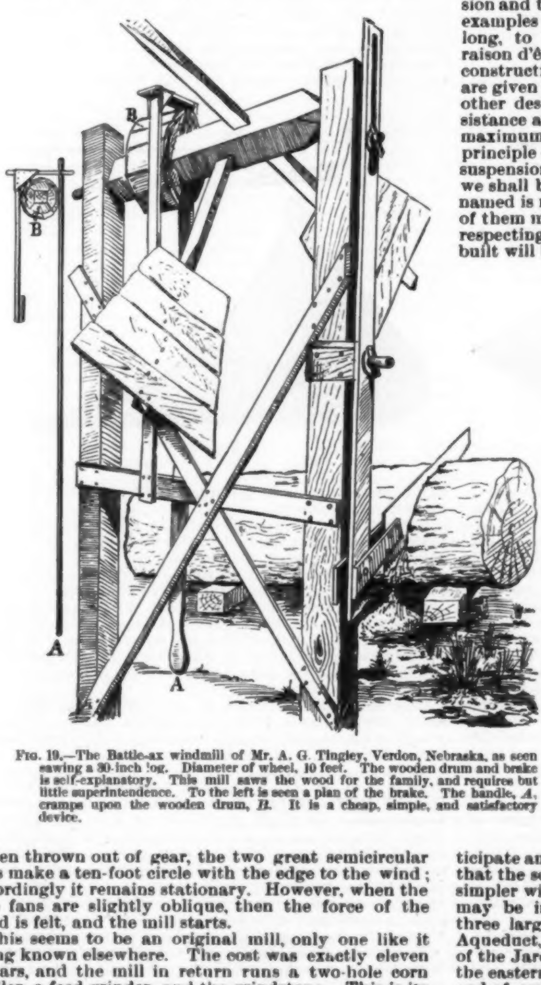


FIG. 19.—The Battle-ax windmill of Mr. A. G. Tingley, Verdon, Nebraska, as seen sawing a 30-inch log. Diameter of wheel, 10 feet. The wooden drum and brake is self-explanatory. This mill saws the wood for the family, and requires but little superintendence. To the left is seen a plan of the brake. The handle, *A*, cramps upon the wooden drum, *B*. It is a cheap, simple, and satisfactory device.

When thrown out of gear, the two great semicircular fans make a ten-foot circle with the edge to the wind; accordingly it remains stationary. However, when the two fans are slightly oblique, then the force of the wind is felt, and the mill starts.

This seems to be an original mill, only one like it being known elsewhere. The cost was exactly eleven dollars, and the mill in return runs a two-hole corn sheller, a feed grinder, and the grindstone. This is its practical efficiency; its true efficiency will be measured and reported at another time.

(To be continued.)

THE DEVELOPMENT OF THE ARCH PRINCIPLE.

IT cannot have escaped the attention of engineers that during the last twelve, or perhaps fifteen, years the principle of the arch, in its application to metallic structures, has been successfully developed to an extent which was neither expected nor predicted of it.

FIG. 18.—The Schroeder barrel-stave, Battle-ax mill, four miles north of Grand Island, introduced to show that almost any waste material may be used in the construction of the homemade mill. The writer has seen new lumber, old lumber, weather boarding, laths and shingles, grocery boxes, barrel staves, tin from old roofs, coffee sacks, and old bagging, canvas, etc., turned to good account in making homemade mills. Old barrels are procurable everywhere, and the barrel staves furnish lumber at once light and strong enough for the fans of Jumbos, Battle-axes, and other inexpensive mills.

In this respect the arch must be viewed in a different light from that in which we should regard the suspension and the cantilever designs. These last-mentioned examples always have belonged, and always will belong, to the type of long-span bridges. Their very raison d'être is part and parcel of those two systems of construction, and, in fact, it is not until dimensions are given to them far exceeding those allotted to any other description of bridge, that their powers of resistance and spanning capacities can be utilized to a maximum. We do not intend at present to place the principle of the arch is competition with that of the suspension, or with that of the cantilever, but we think we shall be able to convince our readers that the first-named is not by any means so far to the rear as some of them might be disposed to imagine. A few words respecting some of the materials of which arches are built will be necessary, as it would be hopeless to anticipate any further development in several of them, so that the sooner they are eliminated from the list, the simpler will be the task before us. In this category may be included brick, stone, and cast iron. The three largest stone arches are those of Cabin John Aqueduct, Washington, D. C., with a span of 220 feet; of the Jaremize railway bridge over the river Pruth in the eastern part of Austria, which can boast of 213 feet; and of our own Gloucester Bridge, 200 feet in span, over the river Dee at Chester. In cast iron, the largest span of old Southwark Bridge, opened for traffic in 1819, measuring 240 feet, has never been surpassed; the Pont St. Louis, over the Seine, comes next with 210 feet; and after these we have the two handsome railway structures, the Victoria and Albert bridges, designed by the late Sir John Fowler, for crossing the river Trent by spans of 200 feet each. There is one more type of arch construction, which, although it does not receive very much favor from English engineers, has to a very fair extent been employed not only in America, but particularly on the Continent. It is that of concrete, either in its plain ordinary condition, or in one or other of the numerous compound systems in which that material is combined with different sections of iron or steel, from common hoop iron to rolled joists of considerable weight and strength. The Munderkingen Bridge over the Danube is an arched example, 164 feet in span, and built entirely of concrete; and in Switzerland another specimen, 122 feet in span, has been constructed upon the Monier compound principle, or that of armored concrete. All modern metallic arches may be classed under one of three heads, those with three hinges, those with two, and those which are hingeless. Examples of arches built with one hinge placed at the crown are very rare, and as there are many disadvantages connected with the system, it is extremely unlikely that it will be perpetuated, so we shall not further allude to it. Each of the three classified types has its own advocates, and we shall adduce some excellent modern examples of all three, to show that each practically possesses no marked superiority over its fellows, though there are certain points of difference between them which will be referred to.

There are in America three bridges of large span which closely conform to the separate requirements of one or other of the three classes, and will therefore answer exceedingly well for the purpose of illustration. The first of these is a roadway bridge, erected ten years ago at Minneapolis, crossing the river Mississippi. It consists of two arches, each having a span of 456 feet, and a rise of 90 feet, and is, we believe, the largest arched bridge built with hinges at the springings and at the crown in the United States. A fine example of the second type of structure is to be found in the Washington Bridge over the Harlem River in the city of New York, which has two steel arches hinged only at the springings, with clear spans of 510 feet, each a rise of 92 feet, and enjoys the reputation of possessing the largest arch ribs constructed with a solid web of any other bridge. The ribs are 13 feet in total depth, the plates in the web are strengthened by stiffeners arranged in a radial direction, and the pins at the springings of the arch are 18 inches in diameter. Large as the span of the Harlem Bridge is for the arch type, it is surpassed by some 30 or 40 feet by two or three other two-hinged structures, of which one may be mentioned. It is that of the Garabit in France, which takes the form of a crescent shaped open-web arch, with a span of 545 feet, a rise of 215 feet, and a depth of 33 feet at the crown. On the Continent, metallic arches belonging to the crescent form, with open-web bracing, are rather favorites. Their particular advantage lies in the fact that they are well adapted for situations in which a lofty bridge is required. That over the Douro has a span of 525 feet, a rise of 131 feet, and a central depth of 33 feet. It only remains now to instance the third or hingeless type, and a better example could not be quoted than that of the St. Louis Bridge over the Mississippi River, better known as the Eads Bridge from the name of its designer, erected about twenty-four years ago. It comprises three spans with fixed ends, of which that at the center measures 520 feet, and each of the side spans 502 feet, with rises of 47 feet and 44 feet respectively. There are four ribs in each span, with chords 12 feet apart, and connected by a series of triangular isosceles bracing. They carry a heavy working load consisting of a double-track railway, and, in addition, an ordinary paved roadway.

Without entering into the relative merits of the three classes of metallic arches it may, perhaps, be conceded that the introduction of three and two hinges in arch ribs is a higher evolution of the prototype with fixed ends, and has, no doubt, contributed to that extension of the arch principle under consideration. Time, further investigations, working examples, and actual practical experience, were all indispensable to effect the change, which, however, is not universal. For instance, the Harlem rigid arch bridge was erected in 1874, but numerous similar designs have been built all over Europe. The latest and the longest span of any hingeless arch was completed so recently as only a couple of

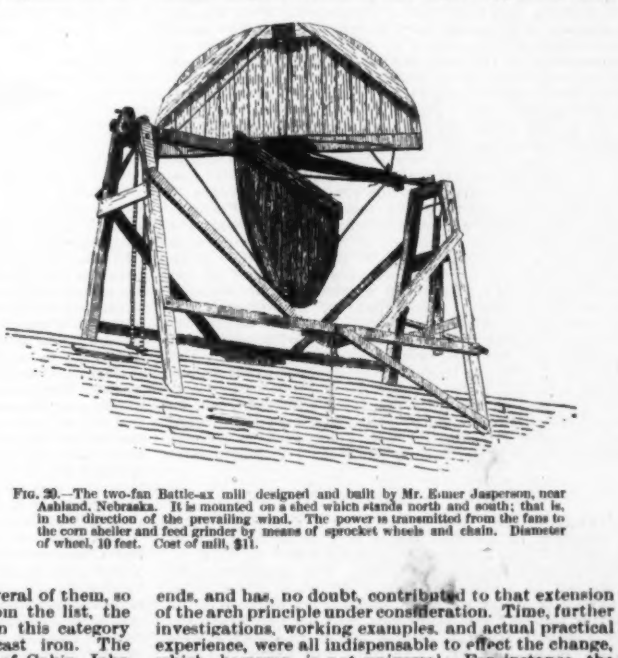


FIG. 20.—The two-fan Battle-ax mill designed and built by Mr. Elmer Jasperson, near Ashland, Nebraska. It is mounted on a shed which stands north and south; that is, in the direction of the prevailing wind. The power is transmitted from the fans to the corn sheller and feed grinder by means of sprocket wheels and chain. Diameter of wheel, 10 feet. Cost of mill, $11.

years ago, and is the Kaiser Wilhelm Bridge in Germany. It has a span of 526 feet and a rise of 223 feet, and fully corroborates our opening statement, that even up to the present time no one of the three types has shown superiority over another to cause it to be abandoned, or its own merits disregarded. The general, although not universal, substitution of the open for the solid web, combined with the introduction of hinges, draws a distinct line of demarkation between the early and the modern examples of arched rib bridges, and points out very conclusively that they are not built as they used to be. This remark will apply to nearly every other type of bridge construction, into which we shall enter upon another occasion, but at present only one claims our attention. During last and the present years two very important arch bridges of spans considerably in excess of those already described have been erected over the river Rhine, the one at Bonn and the other at Düsseldorf. They resemble each other in the following general particulars: They are both road bridges with hinges at the springings, and each carries an electric tramway over it. They are of the single web type, with vertical struts and diagonal ties, counterbraced in the central panel lengths, and the roadway is hung from them by vertical suspending members, having a maximum length of 56 feet, corresponding to each panel in the main ribs. Commencing with the Düsseldorf structure, it consists of two principal arches with equal spans of 598 feet, and five smaller arches, making a total length of 1,362 feet. There are two ribs in each main arch, placed 32 feet apart, and the roadway is supported at a height of 63 feet above mean water level.

The very similar erection at Bonn has a principal single arch with a span of 618 feet, and smaller side spans and approaches, giving a total length to the whole structure of 2,000 feet. Each rib has a depth of 35 feet at the springings, and of 16 feet at the crown, and a rise of 130 feet above the clear waterway, and the upper and lower members are struck from radii of 645 feet and 537 feet respectively. One of the points of difference between these two remarkable bridges is that the wind bracing is differently arranged, and the other, that the platform of the Bonn Bridge is designed so as to possess a higher moment of inertia than that of its neighbor at Düsseldorf. Mild steel produced by the Thomas process was the material used in the construction, and 5,000 tons represented the total weight. When the dimensions of these two structures are considered, especially those of the principal arches, the time, about three years, in which they were erected, compares very advantageously with our latest arch design, that of the Tower Bridge, which, with the insignificant spans of a central 200 feet and side ones of 270 feet, occupied more than twice that period in building. There remains one more example of the arch type to render our list complete, and one which throws all others into the shade. It is that of a steel bridge, which last year was substituted for the old Niagara Falls and Clifton Suspension structure. This magnificent specimen, which belongs to the two-hinged class, has a span of 840 feet from center to center of the terminal articulations, and a rise from the level of the hinges to the soffit of the crown of the arch of 150 feet. This is the largest span of any type of arch in the world, and consists of trussed ribs, with parallel upper and lower members united by diagonal bracing, the depth of the trusses being 26 feet. This stupendous span, as it must be admitted to be for the arched rib system, will soon be followed by another, which will take a good second place. There is at present in course of construction in France, on the railway from Carmaux to Rodez, a bridge which will have a central arch of 726 feet.

In the face of the examples we have brought forward, there is very little doubt that the arch principle has not yet reached its practical limit, but that it will receive further development and practical application. It is also equally clear that the majority of the examples indicate that there is a strong consensus of opinion in favor of the adoption of the type hinged at two points only, that is at the springings. It appears to occupy the happy mean between the other two extremes, being free from the practical disadvantages which have been found to be inseparable from the introduction of the hinge at the crown, and at the same time superior, with regard to the effect of stresses of temperature, to the arch with fixed ends. In point of rigidity and amount of deflection, the hingeless arch ranks first, the two-hinged pattern next, and the three-hinged design last. There is no question that the hinge at the crown of an arch renders it inferior in point of stiffness to the other two systems, from which it results that while the three-hinged structure might be very suitable for light roadway traffic, it would not be found equally advantageous for railroad bridges of long spans exposed to heavy rolling loads. While it would be premature to attempt to fix any approximate limits to the future extension of the arch principle, it is extremely improbable that it will attain to so great a development as to enter into rivalry with either the cantilever or the suspension system. That metallic arches will be erected with spans of a thousand feet and even more, there is no valid reason to doubt, for the arch can hold its own so far, both with respect to economy and stiffness, with the suspension and the cantilever. Beyond this dimension, the cantilever goes ahead, as in the Forth Bridge, which, in its turn, notwithstanding its gigantic spans of 1,750 feet, will be completely extinguished by the new suspension bridge over the river Hudson, at New York, with its stupendous stretch of 3,100 feet in the clear.—The Engineer.

LUMINOUS "VORTEX RINGS."

GREAT interest was created by a paper on "The Production in Rarefied Gases of Luminous Rings in Rotation About Lines of Magnetic Force," by C. E. S. Phillips, says The London Times. The apparatus used consisted of an approximately spherical glass bulb, the ends of which were left open for the purpose of inserting two soft iron electrodes, half an inch in diameter, through airtight flanges which themselves were cemented to the glass. The bulb was about two and a half inches in diameter, and the electrodes were chosen of a sufficient length to enable them, while almost meeting at the center of the bulb, to project outward slightly beyond the rims of the flanges. A side tube was attached for the purpose of connecting the apparatus to a Sprengel air pump and McLeod vacuum gage.

Two powerful electromagnets were then adjusted so as to strongly magnetize the electrodes when necessary. A low pressure having been produced in the bulb by the action of the air pump, leading wires were attached to the iron electrodes to enable the discharge from the secondary of an induction coil to be passed through the rarefied gas. Under these conditions the effects produced in the usual glow discharges by the magnetization of the electrodes could be conveniently examined. The pressure was represented by 0·008 mm. of mercury, and the discharge was just able to pass in the bulb so long as the magnets remained unexcited.

But on shutting off the current from the induction coil and completing the magnet circuit, a luminous ring appeared within the bulb in a plane at right angles to the lines of force and in rotation about the magnetic axis. The number of such rings could be varied by special devices, and their brightness largely depended upon the electrostatic condition of the outer surface of the glass bulb. The effect also depended upon the manner of stimulation of the rarefied gas within the bulb, and the shape of the magnetic field was of importance. The interest of these experiments lies in the fact that they seem to indicate the existence of freely charged atoms (ions) in a gas which has been subjected to electric discharges, the charges being negative.

THE RESISTANCE OF THE AIR.

THE importance of determinations of the resistance of the air to moving bodies, in connection with the problem of aerial navigation and numerous other practical applications, has led the Société d'Encouragement pour l'Industrie Nationale to offer a prize for investigations of an essentially experimental nature dealing with the reactions on a surface moving through the air under varying conditions as to form and velocity. One series of experiments with this object has been undertaken by M. l'Abbé le Dantec, and a second set by M. Canovetti. The following account of these researches is based on the papers communicated by their authors to the Bulletin of the Society, and the report on them by M. Barbet.

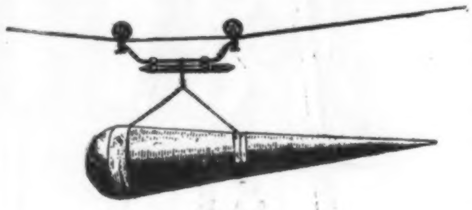


FIG. 1.

The method adopted by M. l'Abbé le Dantec is very simple, and had been used in some previous experiments by him in 1893. It is based on the property that the motion of a falling body is at first accelerated, but the resistance of the air, increasing as the velocity increases, soon balances the weight of the body, and the body thus soon acquires its terminal velocity, and then moves uniformly. The resistance of the air at this velocity is exactly equal to the weight of the falling body.

In the present experiments the surface whose resistance is to be observed slides down a vertical wire, which acts as a guide without introducing perceptible friction. Its weight and area can be easily and accurately measured; and Le Dantec has now devised an electric recording apparatus, which enables the time of fall to be estimated with equal precision. A band of paper is unrolled by clockwork action, and on this band an electric arrangement records the vibrations of a seconds pendulum. Furthermore, when the falling surface is released, a current is started whereby a toothed wheel is brought into contact with the paper band, and traces on it a dotted line. The surface at the end of its descent comes in contact with a buffer, the current is broken, and the cessation of the dotted lines indicates the exact instant at which the surface reached the buffer. The operator can vary the height in such a way that the descent occupies one, two, three or more seconds, and by subtraction the distances traversed in each successive second are obtained.

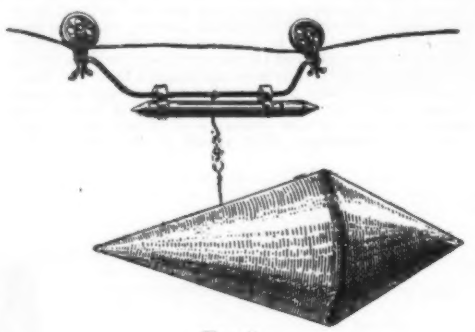


FIG. 2.

The experiments were conducted in the chapel of the Conservatoire des Arts et Métiers, the nave of which is of considerable height, and their accuracy is verified by the perfect agreement of the results. Thus several experiments conducted for the purpose of determining the height through which a surface fell in a certain number of seconds agreed to within a centimeter. The chief conclusions are as follows:

(1) Even feeble air currents such as are produced by persons moving about in the neighborhood of the apparatus suffice to considerably modify the results, and it is important therefore that the experiments should be conducted in a closed building, which must, however, be sufficiently large for the walls not to materially affect the stream-lines of the air flowing past the moving surface.

(2) A square surface 1 meter square, moving with a velocity of 1 meter per second, experiences a resistance of 81 grammes.

(3) Experiments conducted with three different surfaces, each of 1 square meter in area, but of different forms, viz., circular, square, and of the form of an equilateral triangle, respectively, show that the resistance depends on the form of the surface, and the results accord with the hypothesis that the resistance of a surface of given area is proportional to the length of its contour. This property appears to be new.

(4) For velocities varying within certain limits, the law of proportionality of the resistance to the square of the velocity was verified.

The resistance of the air to a moving surface can also be measured by attaching the surface to a small truck which is allowed to descend an inclined plane under gravity. If there were no resistance to motion, the square of the velocity at any point would be equal to twice the product of the vertical height fallen into the acceleration of gravity, but since friction and atmospheric resistance retard the motion, and the latter resistance increases with the velocity, the truck soon acquires its terminal velocity, and in the uniform motion which follows, the total resistance is equal to the weight of the moving body resolved down the plane. By experimenting with the truck alone, the resistance experienced by it can be obtained separately, and by subtraction the portion of the resistance due to the surface under observation is found.

This method forms the basis of M. Canovetti's experiments. Instead, however, of an inclined plane, a copper wire was employed, three millimeters in diameter and 370 meters in length, of which one end was fixed on the side of a hill, and the other on the level ground at its base. This arrangement is similar to that used in many countries where bundles of wood are sent down from the hills by means of a wire. Owing to the wire hanging in a catenary, the lower part of the wire was much less steeply inclined than the upper, the wire even sloping upward near its lower extremity. For this reason Canovetti did not take into account the last ninety meters of the path.

The mode of suspending the various surfaces by a trolley is shown by the accompanying figures. The wheels of the trolley were provided with ball bearings. In order to determine what part of the resistance was due to the trolley itself, the latter unloaded was allowed to descend a wire at an inclination considerably smaller than that employed when it carried one of the surfaces, the smaller resistance of the unloaded trolley rendering a reduction of the gradient necessary in order that the resistance might be calculated under similar conditions as to velocity. The experiments indicated that the resistance of the trolley alone was proportional to the velocity.

In determining the velocity, Canovetti contented himself with reading on a chronometer the instant of starting the trolley and the instant at which it passed a mast placed 90 meters in front of the stopping point. By dividing the 280 meters traversed by the time occupied between the two readings, the average velocity of descent was obtained, and this average velocity formed the basis of Canovetti's conclusions.

The most interesting of these results are those referring to the relative resistances of circular and rectangular planes, and the effects of attaching a cone or hemisphere to a circular disk forming a bow or stern. Canovetti finds that the resistance of the air on an area of one square meter moving with a velocity of 1 meter per second is 90 grammes for a rectangle and 80 grammes for a circle.

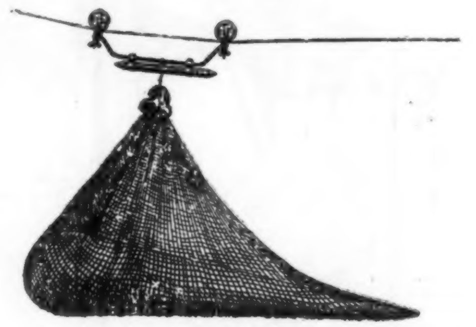


FIG. 3.

A right cone, whose altitude is 1·5 times the diameter of its base, attached to the rear face of the circle reduces the resistance to 60 grammes.

A hemisphere placed in front of the circle as a prow (Fig. 1) reduces the resistance to 22·5 grammes.

Finally, in a double cone, formed by placing a cone of altitude double the diameter of the base in front of the circle, and a cone of altitude equal to the diameter of the base behind (Fig. 2), the resistance is reduced to 15 grammes, or less than a fifth of the original resistance.

Canovetti made a series of further experiments on solids resembling in form the Chalais balloon by suspending a cone and hemisphere, joined by their bases in a net (Fig. 3). In one of these observations the resistance was equal to 80 grammes. This high resistance was due largely to the net, but also in part to the instability of motion, which caused the whole model to undulate. In proof of this latter influence experiments were separately made on models rigidly attached to and freely suspended from the trolley. By taking a model formed of a cone and hemisphere, and attaching it to the trolley by rigid supports fixed one near the common base and another near the vertex of the cone, a coefficient of resistance equal to one-seventh of that of the corresponding circular disk was obtained.

To sum up, then, Le Dantec's experiments appear to have been conducted with every precaution to secure accuracy. The coefficient of resistance which he calculates from determinations made in a room from which

draughts are carefully excluded must be regarded to some extent as the limiting value of a physical constant obtained under conditions which are difficult to realize in practice. We may compare such determinations, e. g., with the determination of the weight of a cubic centimeter of absolutely pure water, since in all probability a large volume of air free from all currents and a cubic centimeter of water free from all impurities, are both of them well-nigh equally difficult of realization. The exact determination of such constants is nevertheless of the greatest scientific interest, and even the difference between their values and those obtained under more normal conditions affords a measure of the allowance that must be made for the discrepancies which exist between theory and practice.

Canovetti's experiments, on the other hand, are essentially of the rough and ready order in several respects. The wire hanging as it does in a catenary, the differences of inclination at different parts of the course render the motion far from uniform over the 280 meters, and the estimated velocities can only be regarded as average velocities in a motion with variable velocity, the details of which have not been fully investigated. A further source of error is due to the sagging of the wire at the point where the trolley rests on it, and the consequent absorption of energy in producing vibrations. It is thus not surprising to find that Canovetti obtains 90 grammes for the resistance of a rectangle where Le Dantec finds 81 grammes; one might not unreasonably have expected a greater discrepancy. Although Canovetti avoided windy days, yet his experiments were conducted in the open air under conditions which might be regarded as normal in ordinary calm weather; and so far as the results bear on the question of the relative efficacies of different forms of balloons and other bodies in overcoming air resistance, they may be regarded as furnishing data of considerable practical value.—G. H. Bryan, in Nature.

THE CATALYTIC PROCESS FOR THE MANUFACTURE OF SULPHURIC ACID.

By FREDERICK H. McGAHIE.

THE most important branch of chemical manufacturing is the production of sulphuric acid. This compound bears to the chemical industries the same relations that iron does to the mechanical lines. So large is the annual consumption of it and so varied are its applications that it has been claimed that the market price of sulphuric acid constitutes a good indication of the state of prosperity of the country. For over a century this acid has been manufactured by a process that has had its natural improvements but that has met no competitor until the present day. There has been evolving in Germany during the last ten years a process based upon principles and apparatus more simple and economical than those involved in the present "chamber process." The results obtained from the few plants in Germany working by the catalytic method are such as to lead to the belief that it is destined to supplant eventually the chamber process, which is founded upon the oxidation of SO_2 to SO_3 by N_2O_3 in the presence of water, and the accompanying formation of H_2SO_4 by reactions embraced most broadly in the equation $SO_2 + O + H_2O = H_2SO_4$.

A brief review of the salient features of a modern plant working in this manner will aid to an appreciation of the differences between the chamber and the catalytic process. SO_2 is produced by the burning of sulphur or sulphide ores in special furnaces in which the air supply is regulated to produce a uniform mixture of air and SO_2, the percentage of the latter varying from 7·5 with ordinary pyrites to 11 with brimstone. This mixture is fed in a steady stream to the bottom of a Glover tower, which is a chamber lined with some acid and heat resisting material like lava or chemical brick and packed with pieces of some similar substance, preferably a good grade of quartz. As the furnace gas works up through the interstices of the packing, it is freed from impurities mechanically carried over from the furnace and has its temperature lowered to a point necessary for the economical working of the process. It meets here the supply of N_2O_3 in a way to be noted later. The oxidation of SO_2 to SO_3 begins in the upper part of this apparatus, so that the gaseous mixture leaving it to enter the first of the succeeding lead chambers consists of SO_2 with a considerable amount of SO_3 and N_2O_3, the diluting air, and some steam furnished by the Glover tower. The chambers in which the H_2SO_4 is formed are built of sheet lead supported by timber framing that is as open as possible to allow the radiation of the heat liberated by the oxidation of the SO_2. Steam is blown into the chambers at various points to carry on the reaction begun by the entering gases. Sulphuric acid forms as a mist, condenses, falls upon the floors, and is drawn off. There are generally three chambers whose volumes are approximately 5 : 3 : 1, the largest one coming next to the Glover tower. Since one of the functions of the chambers is to give the gases comparative rest with time for the reactions to occur, they are decidedly bulky. In the leading chamber over 70 per cent. of the H_2SO_4 is produced; in the second one the rest of the acid is formed; and in the third the remaining gases are dried and prepared for the subsequent recovery of the N_2O_3. In large plants several sets of chambers are employed. The recovery of the N_2O_3 is accomplished in one or two Gay-Lussac towers whose construction is similar to that of the Glover tower. As the remaining gases rise through the packing, it comes intimately into contact with cool and fairly concentrated sulphuric acid that is pumped to the top of the towers and allowed to run down the packing, this acid absorbing all of the N_2O_3 and being supplied so that the acid finally drawn from the Gay-Lussac towers contains about 2·5 per cent. N_2O_3. This nitrous vitriol is then pumped to the top of the Glover tower and permitted to run down through the packing. It is also supplied there with sufficient water or weak acid to dilute it to the degree needed for the freeing of the N_2O_3, which mixes and passes on with the furnace gases. Furthermore, this denitrated vitriol is concentrated to its original strength by the hot gases, packing and lining, so that, when it falls finally to the bottom of the tower, it is in condition to be sent back to the Gay-Lussac towers and used there again without any further treatment beyond cooling.

The oxidizing agent, N_2O_3, is derived from the breaking up of nitric acid vapor supplied to the Glover tower at the start. The true reactions that occur in the chamber process have been shown by Lunge to be a complex set in which several oxides of nitrogen take part, but N_2O_3 is the active agent, giving up part of its oxygen to the SO_2, and then being regenerated by the oxygen of the diluting air. Theoretically a certain amount of N_2O_3 should suffice indefinitely; practically there is a small loss that requires the corresponding supply of N_2O_3 from its most convenient source to the Glover tower after the plant has worked up to full running conditions. The acid drawn from the chambers and known commercially as chamber acid contains around 62·5 per cent. H_2SO_4 and is termed for that strength 50° Baumé, in accordance with the markings of the hydrometer scale adopted in the United States. The 0° of this instrument is the point given by its immersion in distilled water at 60° F. Acid containing 93·5 per cent. H_2SO_4 gives a reading of 66° at the standard temperature, this strength being as high as the instrument should be used for. The specific gravity corresponding to the Baumé scale is given by the formula $145 \div (145 - x° \text{ B.})$ The allowable strength of the acid produced in the chambers runs from 45° B. to 52° B. Below this limit nitric acid is formed, representing not only a manufacturing loss, but serious damage to the chambers. Above it the acid will dissolve and carry away too much N_2O_3. Chamber acid is concentrated in lead vessels up to about 60° B. and beyond that in costly platinum pans to 66° B. acid containing 93·5 per cent. H_2SO_4, in which shape it comes on the market as concentrated acid. Lead is necessarily an impurity to be found in all acid made by the chamber process. When the source of SO_2 is pyrites, other impurities are generally present, arsenic and selenium being the principal ones. If it is necessary that these latter substances should be absent, brimstone is used in the place of pyrites. F. J. Falding states, however, that a chamber plant fitted with all the modern accessories, scientifically designed and operated, will produce from pyrites an acid comparable in purity to that obtained from sulphur. It is estimated that 90 per cent. of the sulphuric acid made in the United States is utilized in refining petroleum and in manufacturing acid phosphate of lime for fertilizing purposes. The fertilizer manufacturer wants 50° B. acid and the refiner of petroleum 66° B. acid. Neither one is bothered by any impurities. The storage battery business calls for both weak and concentrated acid, in which lead is the only permissible impurity. This is true also of acids used in pickling iron articles to prepare them for tinning or galvanizing. The drug and the chemical trade in general demand a purity attained by additional treatment of the usual market acid. There is an increasing demand for a good concentrated acid in the nitroglycerin and nitrocellulose industries. It is this growing demand for pure concentrated acid that has furnished the incentive to the development of the catalytic process, which has now reached such a point that those connected with its evolution predict the gradual abandonment of the chamber process for the manufacture of even weak acid.

This new method produces directly sulphuric acid of any desired degree of concentration, even to the pure monohydrate and fuming sulphuric acid, by apparatus extremely simple and condensed as compared with a modern chamber plant. Dry SO_2 gas and oxygen combine readily to form SO_3 when passed at a proper temperature over what are known as the contact substances, platinum black for instance. This action, known as catalysis, is the keystone of the new process. Though this phenomenon had been observed some fifty years before, it was first made the subject of a scientific investigation by Prof. Clemens Winkler in 1875. These studies led to the introduction of several catalytic processes for the manufacture of sulphuric anhydride, SO_3, in which there was then in Germany a small but very profitable business. By absorbing the sulphuric anhydride as formed in weak or concentrated sulphuric acid in a suitable apparatus, sulphuric acid could be obtained of any desired degree of strength. The SO_3 would combine with the diluting water until it was exhausted, giving then the pure monohydrate, H_2SO_4. Beyond this the SO_3 would be dissolved in the H_2SO_4, giving fuming sulphuric acid, for which there is considerable demand, it being needed, for instance, in the refining of the Russian petroleums and especially in the color industry. But these early processes were found too uneconomical in the utilization of the SO_2 and too costly in general to be capable of competing with the chamber process for the production of sulphuric acid. However, the Badische Anilin und Soda Fabrik kept working at the matter and developed their catalytic process for the manufacture of sulphuric anhydride to such an extent that the other manufacturers had to withdraw from the field. For some ten years this company bent its energies to the extension of their process to the commercial production of sulphuric acid. There can be no doubt of its success, for the company has been running a large plant to supply its own needs most successfully for several years. As revealed by patents, the conclusions that the Badische experts arrived at and the improvements that they developed are as follows: "The combination of $SO_2 + O$ produces a large amount of heat. As this reaction occurs only at high temperatures, the mixture of gases must first be heated before they will combine under the influence of the contact substances. This initial heat, added to the heat of the reaction, will, according to the volume of the gas, assume great intensity, rising even to a white heat. It has been found that the practical carrying out of the process of manufacture of sulphuric anhydride is very injuriously affected in many ways by this excessive heat. The iron apparatus is rapidly destroyed by oxidation; the efficiency of the contact substance is deteriorated; the capacity of the apparatus is diminished, and above all the rapidity of the process, which should be as great as possible, is greatly diminished." The trouble lies in the fact that "SO_3 is partially decomposed into SO_2 and O at a temperature slightly higher than that favorable to its formation, while at the same time the combination of $SO_2 + O$ takes place much more rapidly when it first enters the apparatus, thus overheating the whole apparatus from the start. The greater the amount or concentration of the SO_2, the greater the heat and the greater the decomposition of the SO_3 formed." Commercial success demanded the full utilization of the SO_2 delivered by the furnaces. The Badische process solves the difficulty by removing the "harmful excess of heat from the contact substance and the apparatus by a readily controllable means of external cooling." The furnace gases are first purified. This is done by introducing into the hot gases a "stream of gas or jet of steam." This causes the combustion of any sublimed sulphur, and the precipitation of a larger part of the impurities as a slime. The gases are then gradually cooled and subjected to a washing process "until an optical and chemical examination shows the absence of dust, steam, and volatile matter such as arsenic, phosphorus, mercury and their compounds." This purification is strongly recommended in order to secure a continuous and economical working of the apparatus, since the impurities exercise a deteriorating influence upon the contact substance.

After this washing the gases are dried, raised to the temperature needed for the reaction, and sent through the contact tubes. Platinum constitutes the contact substance used in the Badische process, the contact mass proper consisting of some suitable inert body coated by platinum in a finely divided state. This contact mass is "distributed in the contact tube in many thin layers placed above each other on perforated plates, so arranged as to prevent the pressure of one contact layer on the other, and which neither diminishes the effect of cooling the contact tube, nor allows the gases any other passage than through the contact mass." This part of the apparatus is kept down to the proper temperature for the full conversion of SO_2 into SO_3, by the cooling action of a current of gas circulating around its exterior surfaces. The cooling effect can be regulated by varying the temperature or velocity of the cooling gas, the amount of heat to be abstracted depending upon the volume and concentration of the gases passing through the contact tubes. The cooling gas may be either air or the purified and cooled furnace gases. Liquid baths can be used also. The most economical method is plainly that of using the gases themselves and thereby utilizing the heat of the reaction $SO_2 + O = SO_3$ to aid in bringing them up to the necessary temperature for the reaction. From the contact tubes the SO_3 passes into iron chambers where it is absorbed in concentrated sulphuric acid, the resulting fuming acid being diluted afterward to the degree required.

The Farbwerke vormals Meister, Lucius und Brüning, of Hoechst-am-Main, has been granted a patent in England for a process for the manufacture of SO_3 from SO_2 and O, by using the heat of the reaction to raise the gases to the proper temperature for them to combine in the presence of a contact substance, the absorption of the heat being accomplished in a countercurrent apparatus. The interesting claims in the patent specification are, that the total apparatus is very simple, that equipoise of the process is easily and quickly obtained by the increase or decrease of the entering gas, and especially that large apparatus such as are used industrially work, once the process is in action, entirely without supply of heat from outside. This process would seem to be one form described in the Belgian patents of the Badische Company, although I understand both patents have issued in Germany. In addition there are two German patents dealing with the contact substance. Platinized asbestos has been the usual form, the patents covering it having expired some years ago. When it becomes too inefficient through any cause, the platinum has to be dissolved out and chemically recovered. This is avoided in a method patented by the Actien Gesellschaft für Zink Industrie vormals Wilhelm Grillo, and Dr. Max Schroeder, in which "the inert or carrying substance for the active substance (platinum, etc.) consists of any salts soluble in water. When the contact substance has become inactive, the substance can be readily dissolved, purified, and regenerated virtually without loss of platinum." The Vereinigte Chemische Fabriken of Mannheim have recently obtained a patent covering the use of an oxide of iron as the active agent in the catalytic processes.

As to the actual standing of these new processes, both the Badische and the Hoechst companies have been operating successful plants, the Badische for ten years and the Hoechst for over a year. These concerns use a large amount of fuming sulphuric acid annually in the manufacture of colors. The Elberfelder Farben Fabriken was led through a similar reason to investigate the Badische process, and ordered, as a result, a large plant which has been completed recently. It must be remembered that these three chemical companies are among the largest, most wealthy, and most progressive concerns in their line in the world. A competent authority has informed the writer that these three companies employ together about five hundred chemists whose entire time is devoted to experimental work. The adoption of the catalytic process by such firms constitutes a strong proof of its value. The Badische Company will guarantee in selling rights that any plant designed by its experts and operated in accordance with their instructions will produce concentrated sulphuric acid more cheaply than is possible with a chamber plant. Indeed, Robert Hasenclever stated in reviewing in Die Chemische Industrie of January, 1899, the development of the catalytic process by the Badische Anilin und Soda Fabrik, "even dilute sulphuric acid, which for nearly 150 years has been produced in lead chambers, will be made in future to better advantage by means of catalytic action." These guarantees were made by the Hoechst people in an option given by them last summer. For a given output of concentrated acid, their plant would cost, including the royalty, 25 per cent. less than a corresponding chamber plant; the concentrated acid would be produced more cheaply; and the general working of the process would be entirely satisfactory.

The introduction of these new methods in the United States must be gradual. The manufacturers of sulphuric acid are now enjoying a large and decidedly profitable business. The question of royalties has to be taken into account, and there are additionally rumors of patent fights between the rival German companies. It is the new plants that will take up first the catalytic methods. When the acid business becomes dull again and prices tumble to a small profit basis, the advantages of the new processes will appeal to the large manufacturers now operating chamber plants.

ARMORED TURRETS.

MODERN high-power guns have not only affected the construction of naval vessels, but of land fortifications as well. It was impossible to make the walls of fortresses still thicker than they already were, because the embrasures did not permit the guns to sweep the field before them sufficiently, nor prevent the destructive effect of shells charged with high explosives. At first ordinary ship's armor was used to provide the necessary protection. Later case-hardened plates, invented by Gruson in 1860, were employed with considerable success. Against the hard outer surface of this armor, the best steel shot was ineffective; and the softer core was not even cracked. The plates could be any other nation, were the first to introduce turret fortifications extensively in sea-coast defenses. One of the earliest turrets ever used was built by Mougin, but was unable to withstand the severe tests to which it was subjected at Bucharest (1885–1886). Mougin's turret, as shown in Fig. 1, consists of three parts: the turret proper, containing the guns, the platform for the gun crew, and a subterranean chamber in which the auxiliary apparatus is installed. The turret proper is composed of three vertical plates 17¾ inches thick and of two horizontal roof-plates 10·18 inches thick. The turret and its guns project above the ground not much more than 3 feet. Surrounding the turret is a belt of case-hardened armor constituting a barbette and serving the purpose of protecting the turret-revolving mechanism. The turret is centrally supported on a hydraulic pivot; its bottom edge rests on rollers. The inner diameter of the turret is 13·12 feet, the outer diameter is 15·74 feet; each of the three vertical iron plates weighs 17·7 tons, and the covering plates together weigh 18 tons. The armament comprises two large Bange guns; the total number of men required is 29. The method of raising and lowering the turret is so apparent from the illustration that a verbal explanation will not be necessary. The recoil is checked by cylinders containing glycerin and by Belleville springs on the gun carriages. The powder is automatically discharged by electricity as soon as the turret has been turned in the proper direction and the guns have reached the desired position. The turret is turned by the men below in compliance with the commands telephoned by the officers above. So quickly can the turret and guns be manipulated that one shot per minute can be accurately discharged at a target one square yard in area at a range of 1,000 yards.

Revolving turrets possess the advantage of enabling the gunners to reload the gun without danger from the enemy's fire. But the possibility of the turret's being hit is by no means avoided. French engineers have to a large extent obviated this danger by constructing the turret in two ways, pictured respectively in Figs. 2 and 4.

In the one system invented by Col. Souriau (Fig. 2), the turret containing the guns forms practically part of the barbette and rests upon a sheet-metal cylinder connected with a bell floating in a reservoir of water. At one side of the turret a driving mechanism is arranged consisting of gearing which engages a circular rack on the bottom edge of the turret. The turret is raised and lowered by a system of levers mounted upon a platform above the water reservoir and connected with the cylinder. Col. Bussière's turret (Fig. 4) is also raised and lowered by hydraulic means, which are, however, more complicated than in Souriau's system.

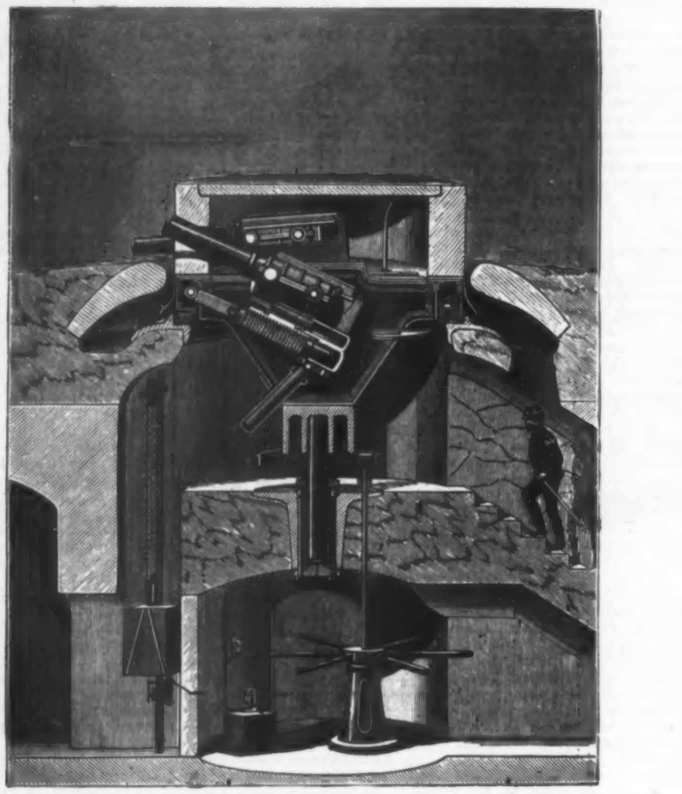


FIG. 1.—AN OLD FRENCH ARMORED TURRET (MOUGIN TYPE).

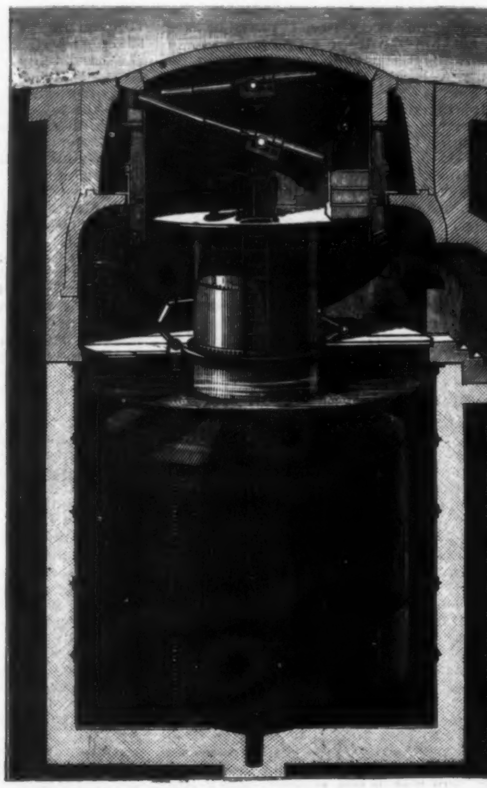


FIG. 2.—SOURIAU'S HYDRAULIC LIFTING TURRET.

made of almost any desired thickness, since there were no limitations imposed as in naval construction.

In the most common method of protecting the guns of a modern fortress, armored turrets are used, which can be turned in any direction to bring the guns to bear on the target. It has been stated by military engineers that a gun which is completely protected by armor and which can be swung with the turret in any direction is three times as effective as a similar gun mounted behind ramparts. Not only is there a saving in guns, but in space as well. An ordinary fort with thirty rampart guns costs at least three-quarters of a million dollars; whereas a fort with three revolving turrets, each containing two guns, and with six pieces mounted behind ramparts, would hardly entail an expenditure of more than two hundred thousand dollars.

The first revolving turrets used in land fortifications were exactly similar to the turrets of the contemporary floating batteries or monitors. The French, more than

The latest type of French gun is the invention of Col. Mougin, previously mentioned, and is represented in Fig. 3. The arched roof of the turret rests upon a substructure of riveted steel plates, supported by rollers, held in position on the concrete foundation of the turret by pins. Within the riveted plates constituting the side walls or substructure of the armored roof, the carriages of the two guns are mounted. From the time of their first introduction in France, turrets have always been armed with guns mounted in pairs and fired simultaneously by electricity. The carriages are provided with hydraulic recoil cylinders. The guns are given a proper elevation by means of a pinion and segment rack.

The concrete foundation of the turret rests upon masonry, in which a vault is formed for the storage of

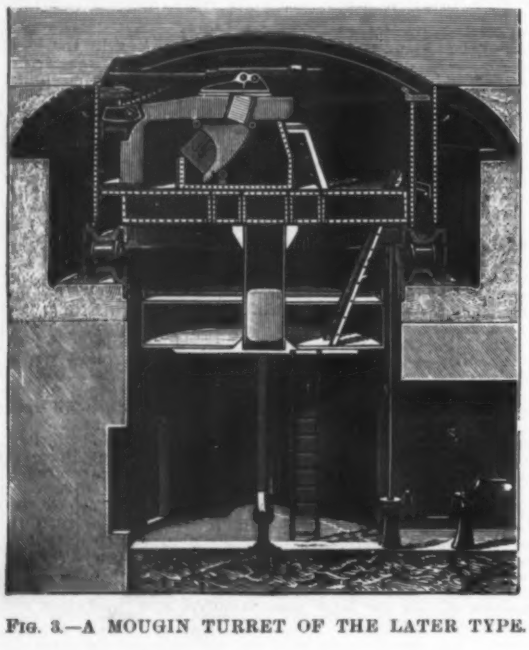


FIG. 3.—A MOUGIN TURRET OF THE LATER TYPE.

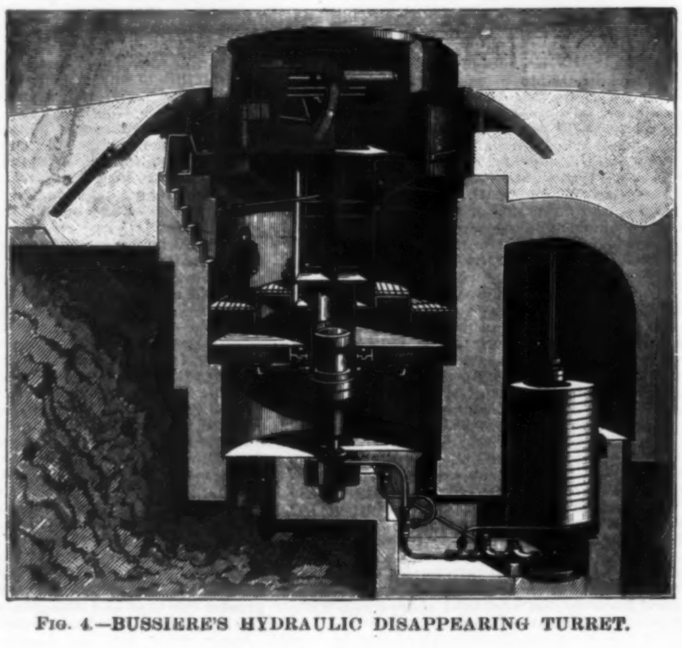


FIG. 4.—BUSSIERE'S HYDRAULIC DISAPPEARING TURRET.

ammunition and the installation of the winch whereby the turret is rotated. By means of a simple ammunition hoist the powder and shot are brought to the first platform and are carried up the steps to the gun. The turret completes one revolution in two minutes. Fresh air is supplied by ventilators.

The most noteworthy improvements in the construction of armored turrets have been made by Gruson. By using case-hardened steel and completely changing the interior construction he produced an entirely new type of turret, in which only the cylindrical form is retained. From the dome-like top of his turret projectiles are so deflected that no injury whatever is sustained by the plates.

The guns, instead of being disposed in turrets, can also be mounted *en barbette* as on board ship, the gun being discharged over a fixed steel parapet and protected by a shield, through the vertical slit of which it projects. Disappearing carriages, invented by Moncrieff and improved by Armstrong, Buffington, and Crozier, have also been used. The gun with its carriage is mounted on a turntable in a walled or armored trench and is protected by a flat shield. The type of disappearing gun most widely used in the United States is the Buffington-Crozier, in which the energy of the recoil is absorbed partly by raising a counter-weight and partly by the resistance of the hydraulic cylinders. The piece is hauled down in loading position behind the parapet, so that the gun crew is completely protected. An 8-inch gun mounted upon a disappearing carriage can fire eleven shots in twelve minutes. When in the loading position, the gun is completely covered from a shot arriving at an angle of 7 degrees. The field of fire is 127 degrees, and the pointing of the gun can be varied from 12 degrees elevation to 5 degrees depression.

A battery of disappearing guns is particularly effective in coast defense. An attacking fleet, even though it know the position of a fort, cannot place a shot within the parapet because high-angle fire is impracticable on board ship. The loading and sighting of the gun is all performed under shelter. The invisibility of such a battery, its absolute protection from gun fire, its steady platform, and the moral effect upon the courage of the crew constitute its chief merits.

THE MORS CARRIAGE.

By VELOX.

THE intention of this article is to give a review of the motor, mechanism, and general details of the now well-known motor vehicles manufactured by the Société de l'Electricité et Automobiles Mors, Grenelle, France.

Peculiarly enough, says The Motor Car Journal, of London, although a large number of these vehicles have been sold in this country, there does not at present exist any general description of the vehicle, its motor and mechanism, and it is proposed to fill this void by the present description.

Speaking in general terms, the mechanical details of the Mors carriages are held by "the man in the street" to be particularly complicated and difficult of ready description. This, however, is one of the many popular errors existing in regard to all types of motor vehicles; and although to the tyro the "complications" may appear excessive, it is hoped that these articles will entirely dispel any such delusion, and at the same time afford users and possible purchasers of the Mors vehicles a ready means of becoming intimately acquainted with the "internal economy" of perhaps one of the many French motor vehicles imported into this best country.

For the purpose of making this description more valuable, it is proposed to take the most popular form of these vehicles, the 8 horse power dog cart, fitted with engines having four cylinders and the customary form of electrical ignition apparatus. The vehicle itself is of a particularly happy form, in that its general contour accommodates itself most readily to its mechanical equipment. It must be understood, however, that the following description applies not to the "dog cart" only, but to all forms of vehicles equipped with the four-cylinder engine of these makers; for whatever the form of the body may be, the mechanical details remain unchanged.

Before proceeding to describe the various parts in detail, it will perhaps be better to briefly pass in review the general arrangement of the mechanism and equipment. The motor has four cylinders placed in pairs at an angle of 45°, each pair forming an angle of that degree with its fellow pair. This arrangement of the cylinders not only materially economizes space, but permits the development of such a power in a given space as would be impossible were any other disposition of the cylinders followed. Besides economizing room both in height and width, this arrangement permits of easy lubrication, and, indeed, these inclined cylinders possess all the advantages of vertical motors so far as perfection of lubrication is concerned. In engines having cylinders placed horizontally, it is generally known that the uniform distribution of the lubricating agent is a matter of very considerable difficulty. By inclination of the cylinders in the Mors motor, this difficulty is obviated. The four cylinders are kept cool by a compound system of heat radiation. The crank ends of the cylinders are cooled by means of radiating disks placed circumferentially around them, while the heads of the cylinders—that is to say, the explosion chambers and the parts adjacent thereto—are cooled by means of a constantly circulating stream of water carried in a jacket surrounding the walls of the cylinders.

The ignition of the explosive charges of gaseous vapors is effected by electricity, and it is perhaps owing to the perfection of the system adopted that the Mors vehicles are so generally successful in operation. When the motor is first started, the necessary current is taken from a battery of accumulators. When the motor attains its proper speed, however, the source of supply is cut out, and the current is furnished directly by a small dynamo actuated by the motor itself; subsequently any excess of current generated by the dynamo is utilized to recharge the accumulators used when first starting the engine.

Power is transmitted from the motor shaft through belts to a secondary or intermediate shaft, and from thence to the road wheels through chains by means of sprocket wheels. The changes of speed and the putting of the motor in and out of gear with the road wheels is carried out on the intermediate shaft. Lubrication is automatically effected by means of a system of chains and spur wheels fixed on the motor shaft, and the circulation of the cooling water and the driving of the dynamo are also controlled by similar means.

The driver of the vehicle has the whole of the controlling mechanism well within his reach. As these various parts are described in detail, the extreme convenience of the arrangement of these items of the control mechanism will be increasingly appreciated. The seating arrangements are such that the driver suffers no interference of vision, although one passenger, or even two if necessary, can be carried on a seat in front of him. In front of the driver is placed a handle bar somewhat similar to that of a bicycle, by means of which the direction of the vehicle is controlled. This handle bar carries two handles, one being horizontal and the other placed vertically at right angles. It is thus possible to steer the carriage with either hand or with both, although it is generally customary to use the left hand for the purpose, the right hand being left free to manipulate other items of the control gear. The vertical handle is placed on the left hand end of the handle bar, and as the description proceeds it will be appreciated why the left hand is more generally used for steering.

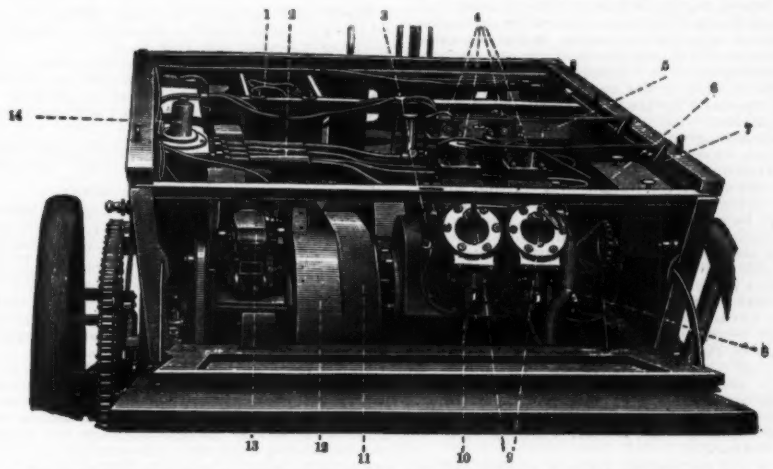
The handle bar is, of course, carried on a steering post, which in its turn is carried in the interior of a vertical hollow pillar. In the center of the handle bar is carried a commutator switch having a dial on which is engraved, in positions corresponding to notches in its edge, the following: "Stop," "Accu.," "Dyna," "Ch. 1" and "Ch. 2." When it is desired to start the motor, the switch is turned from "Stop" to "Accu.," and the accumulators at once commence to supply current to the induction coil, and thus the necessary "sparks" are furnished for the explosion of the gaseous charges in the motor cylinders. The first impetus of the motor has, of course, been given by means of the customary starting handle usual with all types of impulse engines.

Before the starting handle is used, however, the driver has of course opened the cocks controlling the admission of air and spirit to the carbureter. These cocks are placed on the right hand side of the driving seat at about the height of the calf of the driver's leg when seated. They are thus within easy reach of his hand. Equally, of course, he has opened the quantitative control cock for the admission of the gaseous charges to the cylinders. This is controlled by a small lever working in a rack placed on the outside of the carriage on the right hand side in such a position that it is reached easily when the right hand is permitted to hang naturally outside the car.

On the left of the driving seat, at a level with the seat itself, is placed the gear controlling the tension of the belts. This consists of a vertical rod, terminated at the top end by a crank handle. This rod actuates the tension gear through the medium of a crown and worm wheel arrangement duplicated on the end or side of the car. The two endless screws draw forward or drive backward, the bearings resting on slides and carrying the secondary shaft. These bearings are kept in perfect parallel by the synchronous movement of the two screws. By this arrangement the secondary or intermediate shaft is withdrawn further from or is driven closer to the main or driving shaft, with the result that as these movements occur, the belts carried on the pulleys of these shafts are tightened or slackened as the case may be. By the extreme delicacy of the adjustment it is possible to secure just that exact tension under which the motive power is best communicated.

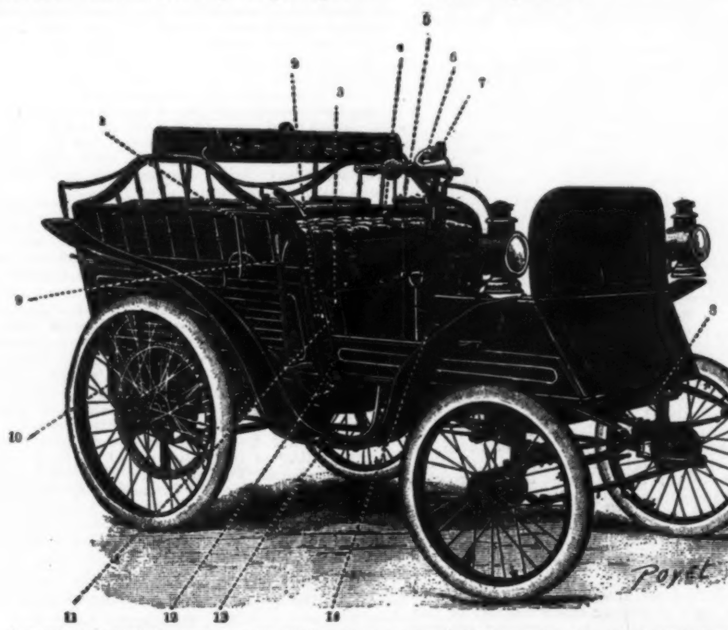
On the steering pillar, underneath the handle bar, are two hand levers, which communicate through the medium of rods with the belt-shipping devices. One handle is used to ship the belt from the loose to the fast pulley of the high speed gear, and the others to effect a similar service in regard to the low speed gear, the fast or live pulleys in both cases, of course, being carried on the secondary shaft.

Apart from the speeds obtainable by these two posi-



1, case containing the four self-induction coils; 2, the four tubes conveying the cooling water from the cylinder walls; 3, inclosed crank chamber; 4, four disks controlling the admission of explosive mixture to the four explosion chambers, and controlling the quality thereof; 5, carbureter; 6, Hamelle automatic lubricator; 7, articulated arms, actuated by moderator lever, and controlling the disks admitting the explosive mixture to the cylinder; 8, exhaust pipe communicating from the exhaust valves to the exhaust chamber; 9, exterior view of the electric ignition or sparking device; 10, one of the four pipes conveying water to the cylinder walls; 11, high-speed pulley; 12, low-speed pulley; 13, dynamo for generating current; 14, bouchon of the smaller water reservoir.

FIG. 2.—VIEW OF MOTOR AND TRANSMISSION GEAR OF MORS DOG CART AS SEEN FROM REAR.



1, quantitative control of gaseous charge to cylinders; 2, cock controlling spirit supply to carbureter; 3, admission of air to carbureter; 4, belt tension; 5, lever for transferring belts from loose to fast pulleys; 6, commutator switch; 7, interrupter switch for cutting out current; 8, cooler or condenser; 9, brake lever; 10, exhaust box; 11, lever controlling "Devil" or "Sprag"; 12, axle of "Devil" or "Sprag" lever; 13, pipe for circulating water; 14, pedal controlling brake and connected to belt-shipping gear.

FIG. 1.—THE MORS DOG CART, GENERAL THREE-QUARTER FRONT VIEW, SHOWING DETAILS VISIBLE WHEN VIEWED FROM THIS POSITION.

tive speeds, the driver has command of the whole gamut lying between and below them by manipulating the tension gear. Furthermore, he has additional power to increase or diminish his speed by a moderator controlled by a small lever working in a ratchet and placed at the driver's right hand on the outside of the car as previously mentioned. The working of this lever requires no appreciable effort, thanks to the multiplication of its movement through a series of articulated levers, and by its aid the most complete control of the speed of the car and its evolutions can be maintained.

Under the levers controlling the belt-shipping device is another handle which completes a vertical rod. This actuates the reversing gear. Two foot pedals placed on the footboard complete the control gear proper; one placed for operation by the left foot throws the motor out of gear with the transmitting mechanism, operating an ordinary type of male and female friction clutch; the other, placed for operation by the right foot, controls the brakes, and at the same time also operates the clutch gear and throws the motor out of operation. The "devil" or "sprag" used to prevent the descent of the car when stopped on a steep hill is operated by the lever 11, shown in Fig. 1 of our illustrations.

Before commencing a further general description of the mechanism, we desire to again allude to the vertical handle, fixed on the left end of the handle or steering bar. At the top of the handle is a button, which is, in fact, a spring cutting out the switch, permitting the current to be cut off from the ignition gear by the mere pressure of the thumb of the left hand while the hand itself is manipulating the steering handles. By this device also the speed of the car can be further controlled, and in dense traffic the ability to at once stop the passage of current to the explosion chamber is of extreme advantage, as the number of successive explosions can be regulated at will.

Passing now to Fig. 2, it remains to be said that the whole of the body of the carriage can be removed at once from the frame, etc., by simply unscrewing four nuts and lifting the body en bloc from the frame. When this is done, the illustration given in Fig. 2 gives a correct exposition of what is seen when standing at the back of the car.

This view of the mechanism gives at once a perfect conception of the whole of the mechanical organism of the car immediately at a glance. The motor, of course, first appeals to one's vision. In Fig. 2 the posterior pair of cylinders are at once seen; the front pair, however, are concealed by the first-mentioned. The cooling radiators placed round the back pair of cylinders are plainly seen, while it is also plain that the explosion chambers are equal in diameter to the full extent of the radiating fins owing to their development by a water jacket. Each system of heat radiation contributes its quota to the efficient cooling of the cylinders. At the end of the explosion chamber there can be seen the outwardly projecting ends of the firing device, which will be more particularly described later. The observer's first remark on examining the mechanism from this point of view is one of surprise that the motor instead of being placed centrally in the frame of the vehicle, is in effect placed at one side, the main or driving shaft having a greater length to the left hand than to the right. At first sight it would seem obviously a better arrangement to place the motor centrally, as by such means a more perfect distribution of weight would be secured.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

The Iron and Steel Trade in Germany.—The rapid advance in prices of iron and steel in Germany has been so great as to disturb business and to materially increase the cost to consumers, says Consul George Sawter, of Glauchau. The demand is so far in excess of the supply that many works will only be able to fill half their orders in iron and steel in the coming six months. In many instances it has already been necessary to limit the output, owing to the impossibility of obtaining the raw material. Should this scarcity of iron continue, it will not be long before thousands of laborers will be without work. It is therefore desired that the duties on iron in Germany should be temporarily suspended. The wish is that the importation from abroad of this metal—which has become so valuable—should be facilitated as much as possible, because the German output of iron can not supply the present demand. This is, of itself, a proof of the enormous development of the German industries which use iron and steel in their manufactures. In 1872, the output of pig iron in Germany was 1,988,000 tons; in 1892, it had increased to 4,986,000 tons; and in 1898, according to the provisional returns, it was 7,215,900 tons. But in the United States the production of pig iron has advanced still more in the same period, rising from 2,589,000 tons in 1872 to 11,962,300 tons in the last year. The smallest increase was in England, where the output of iron was about 6,850,000 tons in 1872 and had only risen to 8,937,000 tons in 1897. It is therefore hoped that the German import duties on iron will be temporarily suspended and a helper in time of need be found for the present development of German industries by participating in the enormous output of iron from abroad. It is true, however, that one must take into consideration the fact that in England and more especially in the United States the consumption of iron is just now extraordinarily heavy. But, at all events, anything which tends to facilitate the importation of iron at the present time would prove of very material benefit to those German industries that consume it. It would at the same time prove a weighty and necessary social-political measure if it should transpire, as is asserted in industrial circles, that, unless this course is adopted, many works will have to lie idle for months, owing to their inability to obtain the necessary raw material.

This scarcity of iron is a sign of the continuous overloading of almost all iron industries with orders. The demand is especially due to the requirements of the railway systems and of the shipbuilding yards. At the present time, numerous new lines of railway are being constructed, while on those already existing improvements of all kinds, which have long been deferred, have become a matter of necessity. Electrical industries have simultaneously become gigantic, and to this is added the fact that modern architecture turns more and more to the utilization of iron, and that, too, in enormous quantities. The Imperial Government's orders will decrease materially in a short time, and then, perhaps, the present strong competition in iron industries will become more normal through the falling off of orders. For instance, one of the great Dortmund iron works had last year to increase its hands to the extent of 1,500; and the value of its orders, which on the 30th of June, 1898, amounted to 22,000,000 marks ($5,236,000) in round figures, stood at about 29,000,000 marks ($6,902,000) on the 31st of July of the current year. A large Saxon machine factory has at present about 15,000,000 marks ($3,570,000) worth of orders on hand. This gives some idea of the activity prevailing in important branches of the iron industries in this empire.

Trade and Industry in Costa Rica.—In a report which will be printed in Commercial Relations, 1899, Minister Merry, of San José, says:

The population of Costa Rica, by the census of 1864, was 120,500, which increased in 1895 to 248,500, and is now fairly stated as approximating 275,000. The following figures are applicable to the fiscal year ending March 31, 1899:

Imports, stated in gold valuation.	$4,258,896.04
Exports, stated in gold valuation.	5,659,218.50

The exports were divided as follows:

Coffee	$4,209,569.15
Bananas	923,090.26
Timber and dyewoods	345,439.04
Precious metals	48,788.30
Various exports	132,331.81

The imports of the year 1898 were divided as follows: United States, 44·80 per cent.; England, 19·61 per cent.; Germany, 15·61 per cent.; various, 20·09 per cent.

In the first four months of 1899, the ratio of imports from the United States had increased to 67·25 per cent., owing mainly to the facilities of steam transportation, although it is not pleasant to note that almost exclusively foreign tonnage was employed in this increasing movement of merchandise. The most important imports from the United States consist of flour, machinery, oils, wire and wire fencing, iron pipe, and furniture. The importation of American cotton drilling and prints is also increasing rapidly.

Of the coffee, 56 per cent. went to England, 20 per cent. to the United States, 16 per cent. to Germany, and 4 per cent. elsewhere. Of the bananas, about two-thirds were shipped to New Orleans and one-third to Atlantic coast ports of the United States.

The Costa Rica Railway, from Port Limon to Alajuela, through San José and other principal cities of the republic, with branches, has a length of 137½ miles. It carried in the year 1898, 601,198 passengers and approximately 160,000 tons of freight. Of this railway, the government owns about $400,000 in shares, gold value, and the remainder is English property. It is well constructed with material imported from England. The ties are of iron and practically indestructible.

The Pacific Railroad will have a length of 58·8 miles from San José to the proposed port of Tivives, at the mouth of the Gulf of Nicoya. It is being constructed by American contractors for account of the government with material (except ties) from the United States. There are now completed 9 miles; additional graded, 25 miles; partially graded, 3·8 miles; not commenced, 21 miles. The road is now using one locomotive (wood burner) and numerous flat cars imported from the United States.

Both railways are 3 feet 6 inches in gage.

The railway from Limon to the interior, after it leaves about 10 miles of banana lands, ascends rapidly, passing the city of Cartago at 5,000 feet elevation, the capital, San José, being 3,860 feet above sea level, and consequently on the Pacific slope. It has been an expensive road to construct and runs through beautiful mountain scenery. From San José to the Pacific the American-built road will run through a mountainous region for about half its length and thence reaches the Pacific over comparatively easy grades, with a maximum of 2½ per cent. Both these roads have, unavoidably, many curves.

It must be remembered that mountainous regions in Central America are not barren like the Rocky Mountains and Sierra Nevada in the United States. The rainfall is generally heavy throughout Costa Rica. The mountains are covered to the summits with vegetation, and, except at the summits, with a soil generally rich. There are running streams in every direction, from which, owing to heavy grades, abundant electric power can be developed. It is a beautiful country, and in its elevated region has a healthy climate. The interior is specially adapted to the growth of coffee, which commands a much higher price in European markets than the Brazilian product. The Atlantic littoral is equally well adapted to the growth of bananas of an excellent quality. These two articles are, as may be noted herein, its principal products; the latter increasing rapidly, while the present low price of coffee offers little inducement to an increase of production, although, if the landowner is free of mortgage, there is still a fair margin.

Costa Rica needs a diversification of her products, a point which is now engaging the attention of her government and agriculturists. An excellent quality of cacao, India rubber, and all classes of tropical fruits for export can be added to the production, while the northwestern part of the republic is well adapted to the cattle industry, the republic not producing at this time the cattle it consumes. Angora goats might be profitably raised in the mountains, above the elevation suitable for coffee growing. There are also valuable gold and copper mines in the interior of the republic, this development having but recently commenced with English and American capital.

Costa Rica has excellent harbors on the Pacific, among them Salinas Bay, Port Culebra, and ports on the Gulf of Nicoya. At present, the only one on the Pacific littoral frequently used by foreign shipping is Punta Arenas, connected by rail with the town of Esparta, 15 miles inland, whence there is a good cart road to San José. On the Atlantic, the only seaport of note is Limon, where the government is incurring comparatively large expenditures for sanitary and harbor improvement. The sum of $765,098 gold has been thus far expended, which has been paid about half in cash and half in non-interest-bearing bonds, the work being under control of an American contractor. When the projected work has been completed, Limon should be one of the healthiest ports in Central America.

The wharfage facilities being deficient, the English railway corporation is constructing a new steel pier with depth of water for the largest ships. A moderate supply of fuel for steam purposes is always to be had here, the railway company keeping a reserve stock of English patent fuel (compressed coal blocks) for its own service and for shipping.

The town and shipping are supplied with excellent potable water, brought from the hills back of the harbor in iron piping.

Twenty-six steamships monthly now visit Limon, connecting with ports in the United States, Europe, the Spanish Main, and West India Islands. Eight to ten mail steamships (American, English, and Chilean) now call at Punta Arenas monthly, besides transient steamers and sailing vessels, the latter loading principally hard cabinet and dye woods, ores, hides, etc., for Europe.

One advantage that Costa Rica has over other Spanish American republics is the fact that her soil is largely owned by small landowners, who make their homes there and, as small producers, are interested in a peaceable life. These people are the backbone of the country—industrious, good citizens, averse to revolutions and political excitement. Considering the small area of the republic and the still smaller population, relatively, Costa Rica has reason to congratulate herself upon her advancement. It needs only the commencement of the interoceanic canal to place her and her sister republic, Nicaragua (also a country of great natural resources), on the highway of the world's commerce. When that time arrives, both republics will rapidly and securely advance in the path of material welfare and prosperity.

Treatment of Diseases by Light.—Minister Swenson sends from Copenhagen, December 2, 1899, a letter to a Minnesota physician in reply to inquiries as to the treatment of certain diseases by concentrated light rays. The letter reads:

Dr. Finsen's Light Institute was founded in 1896, for the purpose, as expressed in the articles of incorporation, of making and encouraging investigations regarding the effects of light on the living organism, especially with the view of utilizing light rays in the field of practical medicine.

The corporation numbers among its members men of eminence and recognized authority in the medical profession, such as the professors of the University of Copenhagen in pathological anatomy, anatomy, and common pathology; and the superintendents of the leading hospitals in Copenhagen.

The institute has gained the confidence and aroused the interest of the public to such an extent that it now receives state as well as municipal aid in the way of appropriations. Its success and growth have been phenomenal. Altogether, some three hundred and fifty cases of lupus vulgaris have been treated, in all of which satisfactory results have been obtained. A large number of cases have been treated experimentally for other diseases of the skin, among them erysipelis and alopecia areata. Scarlet fever is to be experimented with. In an interview which I had with Dr. Finsen a few days ago, he told me that the light treatment as now perfected is so effective that there is reason to believe that every case of lupus vulgaris can be cured by means of it. Dr. Finsen's successful treatment of smallpox by means of red light is also very interesting and ought to be widely known.

Both sunlight and electric light can be used for medical purposes. Owing to its latitude, Denmark is not favorably situated for using sunlight; hence the institute makes nearly exclusive use of electric light. The arc lights used are each of 4,000 candle power (ordinary street arc lights are of from 2,000 to 4,000 candle power). Earlier experiments with this method of treatment have failed because the light used has not been powerful enough.

Dr. Finsen is also experimenting with photo-chemical baths to ascertain how far light is instrumental in supplying the skin with blood. He says that the red color of the exposed parts of the skin is caused principally by light. Heat seems to hinder, and cold to further it.

New Guatemalan Steamship Service.—Consul Jenkins writes from San Salvador, November 25, 1899, that the Deutsche Dampfschiffahrts Gesellschaft Kosmos, a line of German steamers running monthly between Hamburg and San José de Guatemala, has announced to the public that in and after the month of December, a semi-monthly service will be established between the above ports; in addition a monthly service between San José and San Francisco, Cal., and intermediate ports, calling at San Diego and making connections with the Santa Fé Railway. The following are the dates of sailing for San Francisco: Tanis, December 2, 1899; Volumnia, January 2, 1900; Ammon, February 1, 1900; Octavia, March 14, 1900; Luxor, April 12, 1900. These steamers, adds the consul, have been running monthly on the coast for some time.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

TRADE NOTES AND RECEIPTS.

Production of Heel Polish.—Carnauba wax, 5 kilogrammes; Japanese wax, 5 kilogrammes; paraffine, 5 kilogrammes; oil of turpentine, 50 kilogrammes; lamp black, 1 kilogramme; wine black, 2 kilogrammes. Melt the wax and the paraffine, and when this has become lukewarm, add the turpentine oil, and finally the lamp black and the wine black. When the black color has become evenly distributed, pour, while still lukewarm, into tin cans.—Seifensieder Zeitung.

Coatings for Iron.—According to Stahl und Eisen, exhaustive tests with iron coatings established above all the superiority of paints containing red led, especially when the painted parts are partially immersed in water. A drawback is the tendency of such paints to harden, owing to the lead oxide combining with the oleic acid of the linseed oil, for which reason the prepared paint should be used up quickly. For the second coat the employment of red lead is no longer necessary. In colors of inferior covering power, the admixture of heavy spar must be regarded as an improvement.

Uses for Old Corks.—Used corks are generally thrown away in the household as something valueless. Yet their utility is manifold. Large quantities are employed for the manufacture of insulating material for steampipes and kettles of refrigerators and freezing plants. The collars of draught horses are stuffed with powdered cork, and a particular kind of tire receives its elasticity from a cork filling. Cork furnishes the best material for bath carpets, but especially for the manufacture of linoleum. Finally all cheap life preservers are filled with cut-up wine corks.—Technische Notizen.

Oxolin a Substitute for Caoutchouc.—Oxolin has been produced by C. Grist as a substitute for caoutchouc in electrical engineering, by saturating tow uniformly with linseed oil, spreading it out on lattice work, and causing heated air to pass through for twenty-four hours. The mass is next squeezed out thoroughly by means of hydraulic presses and worked together by rollers into an insulating material resembling caoutchouc. Although not quite so elastic as caoutchouc, the mass gives resistance to an electric tension of up to 35,000 volts, as well as to a temperature of 115° C. and to chemical reagents. Furthermore, oxolin can be colored ad libitum.—Chemiker Zeitung.

Purification of Benzine.—If ill-smelling benzine is mixed with about 1 to 2 per cent. of its weight of free fatty acid, same will dissolve therein. Next, add about ¼ per cent. of tannin and intermix well. Finally add enough potash lye or soda lye (or possibly lime milk) until the fatty acids have saponified, and the tannic acid is neutralized, and shake repeatedly. After a while the milky liquid separates in two layers, viz., in a salty, soapy sediment and clear, colorless, and almost odorless benzine on top. The latter, decanted and filtered, can be used immediately for many industrial purposes, but furnishes an excellent, pure product, after another distillation. Fatty acid from tallow, olive oil or other fats or oils may be used, but should have as little odor of rancid fat as possible. The so-called elaine or oleine (more correctly oleic acid) from the candle manufacture may also be employed; but it should be previously shaken with a $\frac{1}{10}$ per cent. soda solution, to remove the ill-smelling liquid fatty acids, especially butyric acid.—A. Gawalowski, in Lack und Farben Industrie.

Rubber an Absorbent of Water.—It may astonish some of our readers, says Technische Notizen, to learn that rubber is by no means waterproof, that is to say, the unvulcanized black rubber. The vulcanized article obtains its impermeability by the absorption of sulphur, along with other advantageous qualities; and by the attending heating all moisture is expelled from the otherwise not anhydrous caoutchouc. If the dried caoutchouc is not vulcanized, it quickly attracts water again, a conclusive proof of its not being water proof. Thus, rolled plates of rubber, which are strongly compressed by previous treatment between rollers, are capable of taking up, in two hours, 8 to 35 per cent. of water heated to 60° C. The quickness and thoroughness of the absorption of water is governed by the degree of the compression, and increases with the latter. Thus, in the case of a piece of caoutchouc, which had been for some time subjected to a pressure of 50 kilogrammes, it amounted to 25 per cent. in five minutes. A piece of best Para rubber kept under water of 50° was nothing but a slimy mass after two months. To this behavior may be also due the deterioration in the quality of crude caoutchouc during the importation from the country of origin, and suitable precautionary measures in importing the raw product may perhaps have more influence upon its quality than the place of origin.

Bronze Gilding on Smooth Moldings.—A perfect substitute for dead gilding cannot be obtained by the use of bronzing. The cause of this inability lies in the radically different reflection of the light, for the matt gilding presents to the light a perfectly smooth surface while in bronzing every little scale of bronze reflects the light in a different direction. In consequence of this diffusion of light, all bronzing, even the best executed, is somewhat darker and dimmer than leaf gilding. This dimness, it is true, extends over the whole surface, and therefore is not perceptible to the layman, and cannot be called an evil, as the genuine leaf gold is so spotted that a bronzed surface is cleaner than a gilt one. The following process is the best known at present. Choose only the best bronze, which is first prepared thick with pure spirit. Next add quite a quantity of water and stir again. After the precipitation, which occurs promptly, the water is poured off and renewed repeatedly by fresh water. When the spirit has been washed out again in this manner, the remaining deposit, i. e., the bronze, is thinned with clean good gold-size. Naturally, the bronze must be thin enough to be just covering. The moldings are coated twice, the second time commencing at the opposite end. Under no circumstances should the dry dead gilding give off color when grasping it firmly. If it does that, either the size was inferior or the solution too weak or the mixture too thick.—Maler Zeitung.

MISCELLANEOUS NOTES.

A thermostat has been designed in America to give warning of spontaneous combustion in coal pockets. A compound solder-release thermostat, incased and protected by iron pipe, is placed in the center of every 10 feet cube of coal, both horizontally and vertically. The thermostat has two operating points, one at 155°, the other at 286°, and as these two points are reached, bells are rung and warning given of an approaching fire.

A second report on the bacterial treatment of crude sewage has been issued by the London County Council. The chemical portion of the report, which is by Prof. Clowes, concludes that the bacterial process presents the following advantages: (a) It requires no chemicals; (b) it produces no offensive sludge, but only a deposit of sand or vegetable tissue free from odor; (c) it removes the whole of the suspended matter, instead of only about 80 per cent. thereof; (d) it effects the removal of 51·3 per cent. of the dissolved oxidizable and putrescible matter, as compared with the removal of 17 per cent. only as effected by the present chemical treatment; (e) the resultant liquid is entirely free from objectionable smell, does not become foul when kept, and maintains the life of fish. The bacteriological portion of the report, by Dr. Houston, includes investigations on the number of bacteria present, and the percentage of liquefying forms, also of the bacteria met with, such as the B. coli communis and B. enteritidi sporogenes, with a description of several species. The report is illustrated with a number of diagrams and photo-micrographs.

Prof. J. B. Johnson, of the University of Wisconsin, in a recent inaugural address which he delivered as Dean of the College of Mechanics and Engineering, made some interesting remarks relative to too strict specialization. Thus he referred to the education of the chemist who in after life was obliged to take up the subject from an industrial standpoint. In nearly all large manufacturing industries in which chemistry is in any way concerned there are two distinct classes of officials, one of which devotes itself to engineering problems, while the other takes up the chemical side of the question, and it is difficult to strike a balance between these two departments, so that if the concern is prosperous the expert chemist goes to the wall, but if the undertaking is not successful, owing to competition with new methods, the chemist is called in to advise, and he too often has little knowledge of commercial processes. In such work any education which would enable the chemist to design the appliances required in carrying out problems he has successfully solved in the laboratory would be of inestimable worth. Prof. Johnson advocates the formation of a special chemical engineering department for the University.

According to Tschermak, the formation of the color of precious stones and other minerals is not easily explained in the majority of cases. The dye-stuff contained in them may belong to an organic as well as inorganic compound, but almost always its quantity is so small that it does not suffice for a chemical analysis. In the mineral zircon, which is much used as a gem, especially under the name of hyacinth, the yellow, green, red, or brown color can be ascribed to the presence of nitrogen, and the same thing has been proved for the well-known smoky quartz, which is very often erroneously called smoky topaz. The origin of the coloring of the amethyst has not been determined as yet, but the opinion that it was due to the presence of a compound of sulphocyanide with iron has been found to be wrong. In many minerals the color is caused by the presence of chrome. This has been a long established fact as regards certain varieties of garnet, spinel, and diopside (a variety of augite). But other highly prized gems owe their color to chrome, as the red and violet spinel, the ruby, the sapphire, the oriental amethyst, the green zircon, and the topaz of Villarica, Brazil. In the ruby and the sapphire, it is true, chrome could not be discovered direct, but it was established in the opposite way that the combination of the elements constituting the said gems and potassium bichromate produces colorless metals on the one hand, but also red, blue, yellow, and green ones. Thus, numerous other examples might be cited, in which the cause of the coloring of minerals might be ascertained, but a much larger number of colored minerals remains, whose color the chemists have not yet explained.—Engineering and Mining Journal.

Although the tea plant is indigenous to Assam and the Chinese plant is a debased variety, it was unknown in India till 1834. In the previous year the East India Company had lost its monopoly of the China tea trade, and the directors set to work to secure for their own territories a portion of what had become to them a very material business. Seeds and plants of the debased Chinese variety were imported, and with them Chinamen and Chinese methods. The following fifty years were employed in getting away from Chinese methods, of which the outcome is the excellent Indian methods of to-day, which have practically destroyed the export of the Chinese production. Following the success in Assam, tea was planted in Bengal and other provinces, until in 1897 the area of cultivation was equal to 200,000 hectares. Outside of India, China and Japan, the greatest development has been in Ceylon and Java. The principal tea-drinking countries of the world are China, Japan, the United Kingdom, the British colonies, Russia and the United States of America. Excluding Mongolian requirements, the world's consumption may be taken roughly at 230,000,000 kilogrammes per annum, which, including cost of transportation, but not revenue and distributive profits, may be valued at £17,000,000. It is estimated this quantity is sufficient to make 100,000,000,000 cups of tea. The United Kingdom takes the largest quantity, the imports for 1898 being 107,000,000 kilogrammes, or 2·65 kilogrammes per annum per head of population —a good deal less than the quantity consumed by the Australasian colonies. Next to Great Britain comes Russia as a consumer of 42,000,000 kilogrammes, or 0·34 kilogramme per head of population. The United State takes 31,000,000 kilogrammes, or 0·41 kilogramme per head; but then the people of the States consume 5 kilogrammes of coffee per head. Canada consumes 3 kilogrammes per head, and Holland ½ kilogramme.

SELECTED FORMULÆ.

Yolk of Egg as an Emulsifier.—The domestic ointment of Unna, consisting of a mixture of oil and yolk of egg, is miscible in all proportions with water. It is proposed to utilize this fact by substituting a diluted ointment for the gum emulsions in general use, the following being given as a general formula:

Yolk of egg	10 parts.
Balsam Peru	1 to 2 "
Zinc oxide	5 to 10 "
Distilled water sufficient to make	100 "

If desired, 33 parts of vinegar may be substituted for the same amount of water, while oil of cade, oil of birch, lianthral or storax may be substituted for the balsam Peru, and an equal quantity of talc, magnesium carbonate, sulphur of bismuth subcarbonate, may be introduced in place of the oxide of zinc. A further variation in the character of the liquid may be introduced by the use of medicated or perfumed waters instead of the plain distilled water. Where so diluted, as in the above formula, the yolk of egg separates out after long standing, but the mixture quickly re-emulsifies upon shaking. Tar and balsams can be emulsified by mixing with double their quantity of yolk of egg, then diluting by the addition of small quantities of water or milk.—American Druggist.

Insecticides.—

FLEA POWDER.

Naphthalin	4 av. oz.
Starch	12 "

Reduce to fine powder. A few grains of lampblack added will impart a light-gray color, and if desirable a few drops of oil of pennyroyal or eucalyptus will disguise the naphthalin odor.

This is an excellent powder, according to A. E. Ebert (Meyer Bros. Drug.), for the removal of fleas from cats or dogs by rubbing into the skin of the animal and letting the powder remain for a day or two, when the same can be removed by combing or giving a bath to which some infusion of quassia or quassia chips has been added. This treatment is equally efficient for lice and ticks, with which dogs as well as cats are afflicted.

WASH FOR FLEAS AND LICE ON ANIMALS.

Naphthalin	1 oz.
Wood spirit	5 "
Green soap	5 "
Water	20 "

Rub well into the hair and wash the animal the next day. Rarely more than one repetition is called for.

DOG WASH.

Soft soap	2 oz.
Creolin	1½ "
Methylated spirit	10 "
Water to	20 "

Dissolve the soap and creolin in the spirit, and add the water gradually.

CATTLE DIP FOR TICKS.

Dr. Noorgard of the Bureau of Animal Industry finds the following dip useful, immersion lasting one minute:

Sulphur	86 pd.
Extra dynamo oil	1000 gal.

BEDBUG LIQUID.

Resin	1 av. oz.
Benzin	32 fl. oz.
Oil cedar	2 "

The advantage of this solution is that a film of resin is deposited, which prevents the eggs from hatching. Like all benzin or gasolin preparations, this must be used with caution to avoid ignition from contact with light or fire.—A. E. Ebert, in Meyer Brothers Druggist.

INSECT POWDER.

The following is claimed to be especially destructive to water bugs and cockroaches:

Persian insect powder	8 av. oz.
Borax	8 "
Sulphur	4 "
Oil eucalyptus	2 fl. dr.

Cleaning Old Waste.—Whether there is any economy in the purification of old cotton waste that has been used by machine men and for roughly wiping down engines, has often been questioned; but there does not seem to be any doubt about it in the West Philadelphia shops of the Pennsylvania Railway. They are now boiling out old waste, some of which comes from driving box cellars, and this is squeezed first in an air press and afterward boiled in a tank with soda in the water for about an hour. The drying rack consists of shelves of coarse iron netting with sheet iron front. These fit in a boxed-in hot air chamber. The air being forced over steam pipes by a blower and passing around the shelves, soon dries it out. It has been found that cellars are often packed too tightly, and by removing a portion of it the bearings run better. This is believed to be many times the cause of apparently mysterious heating.

Ammonia for Fixing Prints.—M. Defays discusses this subject in Helios, and commences by a mention of Molard's advocacy (as far back as 1855) of ammonia rather than "hypo." Ammonia is now so much cheaper than it was forty-four years ago that the slight additional expense of ammonia over "hypo" is perhaps fully balanced by the convenience of the former. The fixing bath recommended for prints consists of one volume of ordinary liquid ammonia mixed with five volumes of water. Prints on albumenized paper require about five minutes in this bath, collodio-chloride papers about ten minutes, and gelatine papers require from ten to fifteen minutes. No destructive element is imported into the prints, pure whites are obtained, the silver image is not weakened so much as when "hypo" is used, and only a short washing is required. The adoption of ammonia will, he considers, conduce to a higher standard of permanency for silver prints.

THE CANKER WORM.*

By GRANT ALLEN.

IT was Attila's boast, they say—I never met him personally—that where his horse's foot had once trodden, grass never grew again. Chief of the countless hordes of Huns and other barbarians scattered among the northern mosses of Europe and Asia, he swept, the Scourge of God, across the civilized but decrepit Roman empire, and left behind him one broad path of destruction in ruined towns and desolated homesteads. Centuries later, another Mongol, Timur, came forth from the same savage heart of Asia, and built his pyramid of skulls among the lonely steppes to testify to the countless thousands of human lives he had recklessly sacrificed. But these historical plagues of conquering kings, though terrible indeed in their kind, are as nothing in devastating power when compared with the destructive insect armies which from time to time burst over and obliterate whole wide areas of culture. The hosts of locusts which eat their way across the face of a continent might make Attila's boast with greater truth than the ferocious Hun himself could make it; the desolation which follows one of these terrible floods of living things is appalling to behold. And then, does not the very pettiness of the enemy render him harder to engage? Artillery is useless against myriads upon myriads of tiny foes; even railway trains have been stopped in their course in America by hordes of insects. The smaller and more numerous the adversary, the less the chance of engaging him with honor; you kill a million; and straightway ten millions take their place. France has lost more by the phylloxera which devours her vines than by the indemnity she paid to Germany for the war of 1870; and the worst of it is, the Uhlan has gone, but the phylloxera still remains encamped and intrenched in all her vineyards. That tiny fly is an enemy with which treaties and capitulations are impossible; no cession of fortresses will satisfy its greed; no promises of money down or of territory ceded will induce it to forego its conquered provinces.

I propose in this paper to trace the life history of one or two among these famous armies of conquering insects, the Assyrian hosts or Napoleonic hordes of their kind, creatures which are produced in vast quantities at once, and which suddenly appear in devastating numbers over whole areas of country. And I do not think we can do better for a beginning than by taking the case of that too familiar American pest, the so-called seventeen-year locust. American, I say, because in this, as in most other matters, America still "whips creation." When the United States go in for anything, they go in for it as a rule on the huge scale; their vast areas of forest and prairie and wheatfield allow the development of gregarious life in a way unknown to our little peninsular and mountain-severed Europe. Here we have meadow and pasture and copse and heath dividing the soil with corn or turnips; in America, wheat occupies whole square miles in a line, and so affords an easy prey to every aggressive insect. Hence it happens that such pests in the States assume the proportions of veritable armies, and that skilled entomologists have to be employed by government like policemen or soldiers in order, if possible, to check the assaults of the foe by opposing to each its own appropriate natural and hereditary antagonist.

You will hardly be surprised to hear at the outset that the seventeen-year locust is not a locust at all. "Things are not what they seem," the poet tells us; and most plants and animals are so strangely misnamed by popular natural history, that the fact of a creature being called by one name almost suffices to make one conclude it must deserve another. Locusts in Africa are very destructive beasts; a cicada in America is equally destructive; that casual resemblance of habit and practical result was enough to make the American farmer call his own local pest by the name of locust. But if you look at the portrait of the female cicada, as shown in Fig. 15, you will see at a glance that she does not present the slightest resemblance to the true locusts, but that, on the contrary, she is almost identical with the quaint little chirpers which keep up such a ceaseless and emulous concert in the fields and woods of Southern Europe in piping summer time. Wherever vines grow, there you will find the South European cicada busily performing. Its continuous song is faintly pleasing to most people, especially if heard at a little distance; but it becomes disagreeable at last, from its constancy and monotony, and if heard very near it is harsh and grating.

A word or two at the outset about cicadas in general, viewed as a family, may help to put you more at home with the group as a whole; after which, we may proceed to inquire into the domestic concerns of the seventeen-year cicada himself in particular. Cicadas in the lump are large and stout-bodied insects, of the beaked class; they are very musical in their tastes, and have wings which are arranged slantwise, like the roof of a house. Their food is strictly vegetarian. Like all their kind, they are specially adapted for living by suction, draining the juices of the plants on which they fasten. For this purpose they are provided with an elaborate and highly developed beak, intended for piercing the tissues of the food plant. The females have also a stout and horny egg layer or ovipositor, extremely complex in its mechanism, as I shall show hereafter; and this egg layer is equally designed for making incisions in the tissues of plants, and laying the eggs where the young grubs, in their earliest stage, will be safest from attack and surest of rich and nutritious provender. Cicadas have always two large and very prominent eyes, set sideways at the edge of the head; but in addition to this pair, many kinds have also three secondary eyelets or ocelli, which are placed between the main eyes in the center of the forehead; and these smaller eyes are frequently most brilliant in hue, with a gleam like a jewel's. Otherwise, the cicadas are not remarkably handsome or decorated insects; they reserve the whole of their æsthetic taste for the musical faculty.

As a rule, indeed, you will find that birds and insects specialize their allurements in one or other of these two directions—song or color; the two are seldom found together. Very brilliantly plumaged birds, like the peacock, the birds of paradise, the humming birds, and the parrots, do not often possess beautiful voices; and, per contra, very sweet-voiced birds, like the lark, the nightingale, the thrush, and the linnet, are not usually remarkable for the hues of their feathers. It seems almost as though nature economized in the matter of display; where she attracts by song, she does not think it necessary to attract by color; where plumage suffices to charm the eyes of delighted mates, she does not trouble to add music also. So pretty a girl, she says, can do without accomplishments; so accomplished a girl has no need for beauty. Now, the cicadas are, almost without exception, musical. But their song is produced exclusively by the male insects, who are provided for the purpose with a curious resonant, drum-like instrument. It consists of a cavity with a stretched membrane, whose vibration, controlled by

FIG. 1.—THE SEVENTEEN-YEAR CICADA.

muscles, sets up the familiar chirping or stridulating noise so well known to all who have lived in Italy. In warm sunshine these insect vocalists keep up a continuous concert of sweet sounds, intended no doubt to attract the females. Resonators in the body increase the volume of the note, and make it carry further; we had one cicada in our house in Jamaica which sang so loud that we always knew it as the prima donna. We were wrong in the gender, I admit; we ought rather to have said the first tenor; for the females have no song; a fact much commented upon by the malicious Greek poet—doubtless a married man, tied to a loquacious Athenian lady:

> "Happy the cicadas' lives,
> Since they all have voiceless wives."

You can thus tell a male cicada from a female at once, because the large horny plate which covers the stridulating apparatus in the nobler sex is wanting or at least rudimentary in the ladies of the species.

But I am too long delaying the introduction of our particular subject, the seventeen-year cicada, who is

FIG. 2.—THE SAW FOR MAKING EGG-NESTS.

really the hero of this present drama. The name is an odd one, but it is strictly true. The cicadas of this kind appear in each district once only in every seventeen years—"And that is once too many," said an aggrieved Kentucky farmer. The fact is, all cicadas remain for a long time underground in the grub condition before emerging in the upper air as perfect insects; and this particular sort takes no less than seventeen years to mature, though there is in certain States a thirteen-year variety or locust species. Fig. 1 of my illustrations shows you a specimen with the wings on one side removed, so as to exhibit the chief offending organs —the mouth or beak, *a*, and the saw-like egg layer, *b*. In the breeding season, the males appear for a short time only, sing, pair, and then die at once, it being probable, indeed, that they cannot or do not eat in the adult or perfect condition. But the females make up for this little defect in their partners' economy by eating voraciously, and laying some four or five hundred eggs apiece in the buds or twigs of trees; after which they, too, proceed to die, having also fulfilled their place in nature. For the winged state in insects is

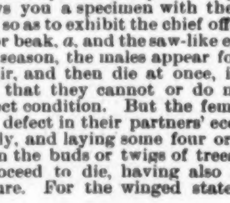


FIG. 3.—SECTION OF THE SAW, SHOWING HOW THE PARTS FIT TOGETHER LIKE A PUZZLE.

usually little more than a device for mating and egg laying; it may be aptly compared to the flowering stage in plants, since the flower exists only for the sake of being fertilized, and fades as soon as the seeds begin to set; its sole use is to attract the impregnating insects, as the sole use of the butterfly is to mate and lay eggs for future generations.

But the ovipositor or egg layer, seen at *b* in Fig. 1, is a most remarkable organ, whose minute structure you can further observe in Fig. 2, where I have had it much enlarged for you. In *a*, this wonderful cutting instrument is seen from above, and in *b* from beneath, the dotted lines being intended to indicate the up-and-down motion of the saw-like blades or cutters. These cutters are fitted together by grooves into the fixed holder or axis almost like a puzzle, so as to move up and down truly; and the cross section in Fig. 3 enables you to appreciate the exquisite way in which the parts

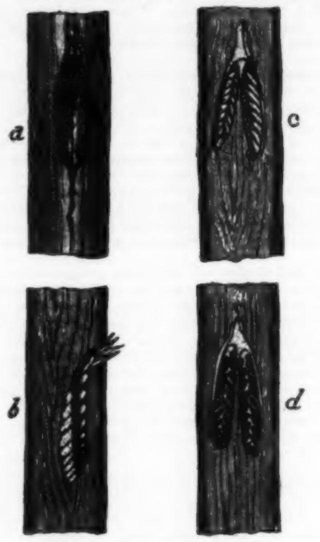


FIG. 4.—NESTS AND EGGS IN TWIGS OF CHESTNUT.

fit into one another, with that extraordinary accuracy only to be found in the works of nature. Fig. 4 again shows you how the mechanism acts as a whole. It exhibits a series of views of the twig of a tree operated upon by the seventeen-year cicada. At *a*, you have a recent puncture drilled by the ovipositor. At *b*, the surface of the twig has been deftly removed, so as to

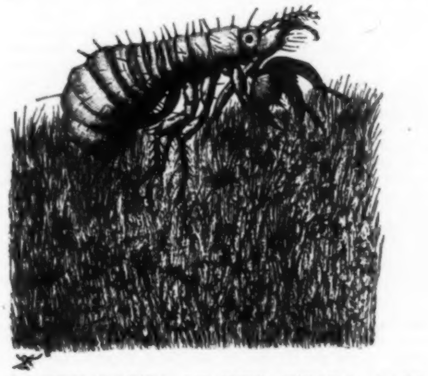


FIG. 5.—THE LARVA OF THE CICADA, AGED EIGHTEEN MONTHS.

show the arrangement of the eggs in the egg basket thus cunningly excavated. At *c*, you have a side view of the eggs lying in their basket; and at *d*, you have the cavity exposed after the eggs are removed, so as to let you see the sculpture left by the ovipositor. I think you will agree that a neater or more perfect nest could hardly be devised than this thus carved out of a living twig by the minute instruments at the disposal of a petty two-inch-long insect.

The eggs soon hatch out in their snug little nest in the twig; but the larvæ do not continue to live there permanently. In a very short time they drop to the ground, burrow their way into the soil by means of their strong-toothed thighs, and fasten onto the roots of trees and plants, where they earn their livelihood by perpetual suction. Caterpillars and other aboveground larvæ, exposed to stress of weather and with

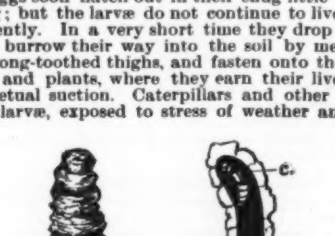


FIG. 6.—THE GALLERIES FOR THE PUPÆ.

the perpetual terror of winter before their eyes, usually live and feed for one summer only; they turn into pupæ during the course of that summer, or at best assume the chrysalis form in the late autumn, hibernating as well as they can in the dormant condition, and coming out as perfect insects with the succeeding springtide. But the cicada tribe pass their larval period for the most part underground, where they are tolerably protected from the inclemency of the weather, for frost never strikes deep; therefore, they need be in

* We are indebted to The Strand Magazine for the article and the engravings with which the text is embellished.

no hurry to grow old apace; they can take their own time for arriving at maturity. And they do take it; they eat their way slowly and laboriously through life; one variety of the periodical cicada matures in seventeen years, the other in thirteen. Meanwhile, the larva lives by suction on roots and underground stems or tubers, doing much unobtrusive damage to vegetation in a quiet way, and eating what he can get with constant vigilance. Of course, he is often eaten in turn in accordance with the usual law of nature; for myriads of the larvæ are devoured by birds, by frogs, and even pigs, which grub them up with their snouts from the soil where they have buried themselves; but myriads more survive, and turn out in the end as fully winged

FIG. 7.—THE PUPA COMES OUT.

cicadas, to the no small disgust of the American agricultural interest.

Fig. 5 is a portrait of the larva, "aged eighteen months," if I may plagiarize the familiar phrase so often used in another department of this magazine with reference to the photographs of more illustrious celebrities. You will see at once that our undeveloped cicada is already a creature capable of doing a fair amount of serious damage to trees or crops; and when you consider that he has still fifteen years to grow, you can understand that he inspires a just fear in the bosom of the farmer who has most to deal with him. Admirably adapted both for sucking and nipping, as this picture shows, he can do as much harm as any insect of his size known to science, with the solitary exception, perhaps, of that famous winged fiend, the true African locust.

At the end of his long and tedious minority, the cicada larva begins at last to think of assuming the

FIG. 8.—AND THE CICADA COMES OUT OF IT.

toga virilis of his race, and prepares to put on the robe of the pupa. But his pupa stage is not like that of the butterfly, an inert and mummy-like chrysalis existence; in common with the great group of beaked insects to which he belongs, the cicada only undergoes what is technically known as an "imperfect metamorphosis." The pupa in these cases does not become dormant; it is merely a sort of active hobbledehoy, which walks and behaves like the larva or the perfect insect; it represents an intermediate form between the grub and the winged cicada—an intermediate form quite as capable of taking care of itself as the perfect animal. For seventeen years vast hordes of larvæ live unseen underground in the same district; at the end of that time, all with one accord begin to change into pupæ, and construct for themselves strange galleries of emergence, so that the soil in certain places seems honeycombed with their tunnels. Two of these galleries are seen in Fig. 6, one in front view, and the other

FIG. 9.—BODY FREE!

laid open as a section. Here *e* is the door or orifice of the gallery, and *c* is a pupa waiting to undergo transformation; while *d* is a brother insect just ready to metamorphose. Whole acres together are being covered and pierced with these strange tubes or shells, as thick as blades of grass in an English meadow.

Fig. 7 shows the next stage in the process of emergence. Here the active pupa has walked up from the ground, and is just preparing to enter upon a new phase of life as a free-winged insect, frequenting the open sunlight. It moves cautiously and slowly, a little dazzled and stunned, like a man brought up for many years in a mine, and then suddenly turned loose in the crowded and garish streets of some great city. No wonder the creatures feel like so many insect Kasper Hausers, and move gingerly about on the branches which support them. The pupa crawls out upon a twig, and finds its skin has strangely hardened. After a while, it pauses, as in Fig. 8, and feels the hardened shell on its back gradually breaking. The winged cicada, which has formed itself within the pupa's skin, now begins to worm its way out with hereditary caution. In Fig. 9 you see it freeing itself from its mum-

FIG. 10.—WINGS AND LEGS ALL OUT!

my case, a pale and ghost-like creature, as yet very timid and uncertain of the future. In Fig. 10, with one long pull, it has got its legs and wings free, but its tail still remains inclosed in the cast-off shell or pupal skin. The wings, you will observe, are at this stage very small, and quite inconspicuous; we shall see hereafter how they plim themselves out in the open air to the adult dimensions. In Fig. 11, the emergence is almost complete, and the perfect insect only hangs by its tail to the cast-off skin of its own pupa. The wings are here seen sideways, and have grown a little larger, but they are still rather thick or fleshy in texture, softly plastic, and wholly unfit for the act of flying.

The three next illustrations show the process of passing into the flying stage. In Fig. 12, the newly em-

FIG. 11.—HOLDING ON BY HER TAIL.

erged cicada has cast itself quite free from the clogging garment of its pupal condition, and is balancing itself on a leaf preparatory to inflating and drying its wings. In Fig. 13, it has poised itself firmly, and is beginning to swell. In Fig. 14, the wings have been fully inflated, like a Dunlop tire, and are now hardened and ready for action. In this stage, the cicada assumes a beautiful glossy and satiny appearance, though it still looks a trifle pallid and ghost-like. The illustrations show you in each case only a single cicada; the American farmer has good ground for knowing that, like other misfortunes, they never come singly. When the moment for emerging arrives, the ground in an infested district seems simply to teem with masses of cicadas; Mother Earth brings them forth; they pour

FIG. 12.—CICADA JUST EMERGED, WITH EMPTY PUPA-CASE.

out in their millions, and devour everything on which they can lay their beaks with ruthless destructiveness. In a few days trees and shrubs are laid bare, crops are destroyed, and the year's labor is rendered vain by the victorious insects. The damage done by them as larvæ during their seventeen years of subterranean existence is as nothing to the damage done by the perfect insects during their short spell of adult activity. In Pennsylvania they have been known to bend and break down the limbs of trees by their weight; the forests ring with the shrill sound of their music.

For now comes the pairing season. Early in June, on every branch around, the male cicadas sit and beat their tiny drums as a summons to their lady loves, in emulation with one another, like nightingales or sky larks. Sometimes you may hear two particularly loud ones singing or drumming in rivalry; as soon as one leaves off for a second, the other begins, like Virgil's swains, in alternate verses. Attracted by the sound, the clustering females alight near the most favored male, and soon select the partner that suits them. In the woods at cicada time you may see hundreds and

FIG. 13.—PLIMMING HER WINGS.

thousands of such little domestic dramas enacted on every side, the boughs being alive with many myriads of eager performers, each surrounded by its own little admiring group of female listeners. All around, the branches of the neighboring trees are covered with a drapery of rent and forsaken pupa cases.

The next stage in the drama of cicada life consists in the deposition of the eggs. Fig. 15 shows us a female cicada, apparently lost in profound thought, and seated lengthwise on a twig of chestnut. But she is not

FIG. 14.—WINGS FULLY EXPANDED.

composing an epic; in reality, she has pierced the tissues of the shoot with her auger-like egg layer, and is now engaged laying her eggs safe out of harm's way among the pigeon holes of one of those neat little nests already illustrated. It is for the sake of producing these eggs in sufficient numbers that the perfect insects—at least the females—have eaten so ravenously ever since they emerged from the pupal form; for they lay about a round five hundred apiece, and they have to devour material enough for this immense production in a week or so of rapid and greedy accumulation. You can't make eggs out of nothing, of course; and the more

FIG. 15.—LAYING EGGS

you have to lay, the more you must eat in order to lay them.

So far, we have dealt mainly with eating and drinking, marrying and giving in marriage, with a slight accompaniment of vocal and instrumental music. But the cicada's life is not always "all beer and skittles." Fig. 16 represents an untoward accident, to which our hero is commonly liable. A parasitic insect, by name Megastizus, smaller than the cicada, but stronger and heavier, seizes it bodily in his legs and carries it off to store his own nursery, exactly as evil spirits carry off wicked souls in old Italian pictures. Megastizus is a burrower, and Fig. 17 shows in a lurid light one of his

underground tunnels, with his own ugly larva engaged in devouring the dead cicada. These burrows themselves are singular examples of insect architecture, Ali Baba caves of tiny robbers; they are represented in ground plan in Fig. 18, a, a being in each case the door or entrance, and b, b, b the little round chambers stored with cicadas in which the eggs are laid and the larvæ developed. The late Prof. C. V. Riley, the official entomologist of the United States, made a special study of the seventeen-year cicada and this its natural enemy; and it is from materials kindly supplied by him to Mr. Enock that our artist has made the interesting sketches which accompany this article.

The last of these destructive insects with which I shall deal here is the dreaded army-worm, a terrible plague of American wheat fields. The whole life-history of this dangerous wild beast is summed up for us in brief in Fig. 19, drawn also from materials supplied by Prof. Riley, who worked harder at the investigation of these insect pests than any other entomologist in Europe or America. No. 1 in this illustration

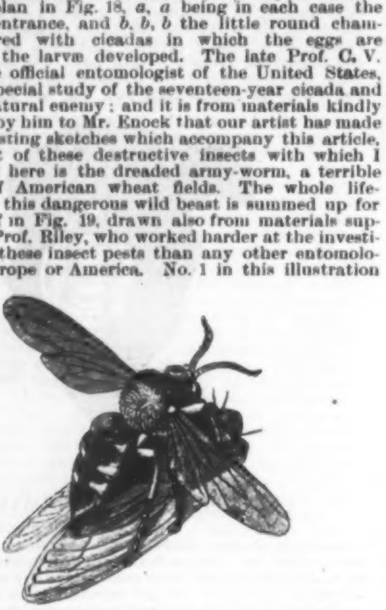


FIG. 16.—CARRIED OFF BY AN ENEMY.

shows the harmless and innocent-looking eggs, quietly deposited by the mother moth on a blade of wheat as it grows. No. 2 gives us the larva just hatched, and proceeding to make a meal on the farmer's young crop. Nos. 3, 4, 5 and 6 show it growing progressively fatter in the process, much to the detriment of the corn; while at 7 it is represented as turning into a pupa, and at 8, 9 and 10 is seen as the perfect insect. This American army-worm commits terrible ravages in the western wheat fields, and sometimes attacks whole districts at once like an invading battalion.

A totally different but still more interesting insect is known by the same name of army-worm in Southern Europe. It is the grub of a midge, and is not separately noticeable; but its numbers make it conspicuous, and its curious habits have always attracted the attention both of naturalists and of farmers. The European army-worm, however, is not in any way a menace to agriculture; it is merely noteworthy from the strangeness and weirdness of its processional habits. The adult midge is a small black fly, no bigger than a mosquito; it lays its numerous eggs among fallen and rotting leaves, which form the favorite food of its myriad larvæ. The eggs hatch out into little naked maggots, about a quarter of an inch long; the body is sticky and almost transparent, but the wee black head gives the tiny beasts a rather knowing expression, like insects of the world, quite at home in society. When the time arrives for the grubs to turn into chrysalides, thousand of families of them collect together among the fallen leaves so as to form a veritable army, which sets forth on a march across country in a serried phalanx, many feet in length, and crawling some sixty or seventy abreast in very irregular order. The line

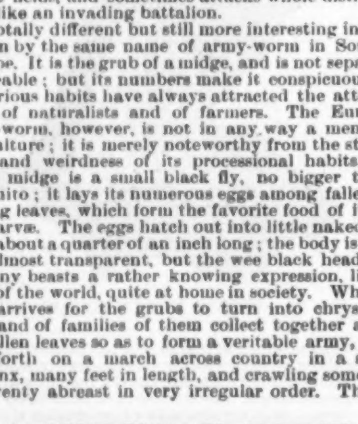


FIG. 17.—THE ENEMY'S LARVA FEEDING ON DEAD CICADA.

flows like a cataract over whatever comes in its way, the individual whitish grubs not being particular whether they crawl over one another or not; and as they wind in and out, around trunks of trees and gnarled roots or stems, they resemble nothing so much as a huge gray snake trailing slowly through the brushwood. The line seethes with life; it is a living stream, composed of translucent and viscid insects, so fluid and plastic in its mode of progression that you have to look close before you can convince yourself that it is really made up of individual maggots.

At last the army reaches a suitable place for undergoing its metamorphosis. Then instinct teaches it what to do. It halts by common consent, and the various grubs roll themselves up into a huge round ball, which seems for a time to be perfectly motionless. If you watch it long, however, you will soon begin to perceive that it is growing by degrees mysteriously smaller and smaller. Can the grubs be eating one another up, like the Kilkenny cats? It looks as though the mass were disappearing slowly into thin air; only when the ball has begun to reach its last few layers do you get an inkling of the explanation of the mystery. The larvæ have chosen a nice soft spot in the deep black mold of the wood, where they can easily bury themselves to undergo transformation. Those at the bottom of the ball first burrow into the ground, and are followed one by one by the others in succession. There they all assume the form of small mummy-like pupæ; and after passing through their transformation underground, emerge at last as a vast and tangled swarm of small black midges, dancing in the sunlight with rhythmical motion. But though the

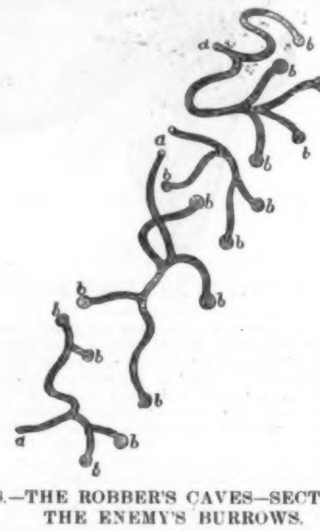


FIG. 18.—THE ROBBER'S CAVES—SECTIONS OF THE ENEMY'S BURROWS.

European army-worm is really quite harmless, being a member of the rather innocuous or useful group of fungus-eating midges, the occasional appearance of the armies across a grassy path has always been a cause of superstitious terror to the peasants of the wild and tangled forest-lands which the creature frequents. Strange stories are told and believed about these innocent little grubs: their advent is a sign of impending war; they are the harbingers of invasion; they herald misfortune like comets and earthquakes; they even appear as portents of God's wrath before the occurrence of plague, famine, and pestilence. In New Orleans and other American towns exposed to yellow fever, it is believed that a closely similar midge, the so-called "yellow fever fly," accompanies the epidemics of that dreaded disease. But it is not improbable that the microbe of yellow fever may really be spread by means of midges, so that in this respect the current belief of the New World rests perhaps upon a firmer basis than the antique superstition of the European woodlands.

KAURI GUM.

NEW ZEALAND is a country rich in the great variety of its forest trees; most of them useful, all beautiful, but none to compare with the Kauri pine, either for stately beauty or commercial value. This noble tree

FIG. 19.—LIFE-HISTORY OF THE ARMY-WORM.

attains a height of nearly two hundred feet, and a diameter of fifteen or even more. Its stem, or barrel as the bushmen call it, rises from 30 to 70 feet without knot or limb, then branches into an even head of dark green foliage. At the place where it forks the stem is almost the same in circumference as it is 6 feet from the ground, and, as it has a bark colored in various shades of red or brown, it gives one the impression of a beautiful pillar at the entrance of some woodland temple. Every tree is surrounded by a mound of fibrous soil consisting of decayed leaves, bark, etc., the accumulation of centuries, for the Kauri is extremely slow in its growth. These mounds rise from 2 to 6 feet in height according to the age of the tree. But the most remarkable thing about the Kauri is the quantity of resinous gum which is shed from every part of it. This gum first exudes from the tree as a thick milky white fluid which hardens rapidly on exposure to the air, eventually becoming clear and almost transparent. In the course of time this gum falls to the ground and is covered by the débris at the bottom, to be found long after the parent tree has disappeared.

Ages ago, before the Pakeha (white man) set foot in New Zealand, the north of Auckland was covered with vast forests of Kauri pine, which stretched in a broad belt along the sea coast from the North Cape to the Bay of Plenty. South of the Bay of Plenty the Kauri never grew, or rather there are no surface traces of it, although the gum has been found in the coal measures as far down as Stewart Island. Of all these mighty forests, there only remain a few comparatively small patches of Kauri; the rest has disappeared, swept away by some great fire or succession of fires. At the present day, helped by the gross carelessness of man, the same agency is at work destroying the few remaining Kauri forests; but quicker even than the fire is the ever hungry saw mill, so that in a very few years a growing Kauri will be about as common as a live moa. . . .

Though the Kauri pines have all but disappeared, yet the gum which exuded from them in their lifetime still lies buried in the ground, and has become a valuable article of commerce, chiefly used for the manufacture of varnish. To find, clean, and prepare this gum for the market gives employment to several thousands of men called gum-diggers, who, owing to their unsettled, wandering kind of life, are looked down upon by respectable people. The gum-bearing country is divided into two classes—the "fern," or open country, which lies for the most part within a short distance of the coast, and the living Kauri forests, or "bush," which are further inland. Most of the fern fields are owned by private individuals or Maori tribes, while the bush nearly all belongs to the Crown. . . .

The absence of all sunshine in the bush makes both Pakehas and Maoris very pale, in fact, a bush digger can always be told by the deathly white color of his face and arms. In the daytime the bush is a very silent place; an occasional whirl of wings overhead, a berry dropped from the top of some tree by a pigeon, an odd note from some solitary tui: these are all the sounds. Squirrels there are none, but the common Norwegian rats try, very capably, too, to take their place. These pests of the diggers have killed all the native rats and have thoroughly taken to the bush, climbing the highest trees with ease, living on berries and pith from the fronds of the tree fern. This animal, seen perched half-way up some tall tree, seems to have grown cleaner and sleeker than his brother of the sewers; in the course of time his scaly tail ought to develop into a brush. As the evening comes down, the bush seems to awake again. A flock of kakaus (large parrots) shriek and wrangle among themselves, quarreling for the best roosting places. The tuis start their evening hymn; far away in the depths of the forest a wild bull bellows; an old razor-backed sow, followed by a litter of brown and gray suckers, comes down to the creek to drink, rooting as she goes.—C. Waterston, in Longman's Magazine.

PHYLOGENY OF RUST.

THE origin of the rust fungi has recently given rise to a considerable amount of discussion, and Professor Dietel, in an interesting paper (Bot. Centralbl., lxxix. Nos. 3-4), considers the question of their descent from one or more plurivorous forms—forms, that is, which inhabited indifferently hosts belonging to the most widely different families of flowering plants. At the present day, however, only one species, a Cromartium, is known to retain this peculiarity, having been shown by Fischer to be capable of life on plants belonging to both Ranunculaceæ and Asclepiadeæ. But Professor Dietel adduces a mass of collateral evidence which seems to show that the balance of probability at least lies on the side of his hypothesis. It would indeed be difficult to account on any other grounds for the close morphological resemblances existing between forms which, while biologically distinct and inhabiting plants belonging to the most widely different families, are at the same time almost indistinguishable by any other features. Triphragium clavellosum, for example, is confined to Aralia nudicaulis, and differs from T. Credelae, which lives on Credela chinensis, merely by the size of the spores, a difference which does not exceed the dimensions of a single micron.

Such forms must obviously be looked upon as having sprung from a common ancestor, which in this case must have lived on both hosts indifferently, especially as the two species agree in the possession of characters which distinguish them sharply from all other Triphragia.

Another example is supplied by Leptopuccinias like P. Arechavaletae living on Sapindaceae, P. heterospora on Malvaceae, P. Elytrariae on Acanthaceae, and P. Lantoneae on Verbenaceae, all of which closely resemble each other in the form of their spores and spore-beds; while all possess in common such distinctive characters as the preponderance of unicellular teleutospores, isolated individuals of which may reach a much greater size than their fellows, and the occasional occurrence of isolated bicellular spores which also vary in size, and the septum of which is often oblique, while the only morphological differences are to be found in slight diversities in the size of the spores and in the thickness of their walls.

Further evidence of the same kind is furnished by the only three Puccinosiras known, and may probably be found in a number of other heteroecious forms.

A striking morphological resemblance is also observable between certain Leptopuccinias and the teleutospores of heteroecious species parasitic on widely different plants, but possessing aecidia which live on the same hosts as the Leptopuccinias in question, e. g., Puccinia aecidii leucanthemi, which forms aecidia on Chrysanthemum leucanthemum, gives rise on Carex montana to teleutospores which closely resemble those borne by the Lepto-form Puccinia leucanthemi on the former host.

Professor Dietel cites a large number of such correspondences, and believes that they point to the origin of the heteroeceious and Leptoforms in a common ancestor inhabiting such widely different hosts as Carices and Composites, while, on the other hand, Professor Magnus is of opinion that the resemblance is purely accidental, and ascribable to the great similarity exist-

ing among Leptopuccinias as a whole, owing to adaptation to their peculiar mode of life.

The coronate Puccinias, including, along with those heteroecious species which form their aecidia on Rhamnus, the two Leptopuccinias also living on the same host, and P. Festucae, which forms its aecidia on Lonicera, are distinguished from all other Uredines by the possession on the teleutospores of a crown of processes which appear to be devoid of adaptational significance and must be considered as pointing to a common ancestry for these forms, especially as the only other Uredine inhabiting Lonicera is Puccinia longirostris, in which the crown is replaced by a single long process on the apex of the teleutospore, but which resembles in all other particulars one of the Lepto-forms inhabiting Rhamnus. Fischer prefers the view that in this case the ancestral form was capable of completing the whole cycle of its life-history, as well on grasses as on various species of Rhamnus, and that its descendants became specialized so as to form either aecidia on Rhamnus, and the Uredo-teleutospore generation on grasses, or the aecidia was dropped and the uredo-teleutospore generation alone persisted on Rhamnus as in the Leptopuccinias in question.

As, however, these give rise to several generations on the same host in the course of each year, Dietel is unable to recognize any sufficient cause for the disappearance of the aecidial generation, and believes a more probable view to be that the ancestral form only bore teleutospores, and that the uredo and aecidial generations originated at a later phylogenetic stage, a hypothesis which receives some support from Brefeld's well known views regarding the origin of the Uredines from the Auricularias, a saprophytic group which possesses no spore form comparable with either aecidio- or uredo-spores, both of which may have originated as an adaptation to a parasitic mode of existence, though not necessarily on all the host plants inhabited by the parent form.—Natural Science.

STRUCK BY A FRAGMENT OF A METEOR.

CONSIDERING the enormous amount of material that comes into our atmosphere from the regions of outer space, and which ultimately reaches the earth, either in the shape of dust, or as large or small fragments of meteoric metals, the number of persons who have been struck by these falling fragments is marvelously small. The writer of this can remember reading of but one well authenticated case, and this happened several years ago, in Ohio, we believe. For this reason the following is of great interest in a scientific point of view, and especially so, as it comes from an entirely trustworthy source. The narrator, Mrs. T. T. Roche, and the party who was struck, Miss M. E. James, both of Mobile, Ala., are sisters of the scientific editor of The National Druggist. Mrs. Roche writes as follows:

"On last monday night (September 3) the weather was so close and hot that I had lain down in the hammock under the big walnut tree in front of the house. Sister M. had taken a seat in the center of the lawn, quite out of the shelter of the tree. I was lying in such a manner that we were directly facing each other, only a few yards apart. Sister was sitting with her arms stretched out and resting on the arms of a large armchair. While we were talking I saw a meteor descending to the earth directly over her head. It was quite brilliant at first, but grew fainter as it came nearer, until just as it seemed to reach her, it was about the brilliancy of a large, a very large 'lightning bug' or firefly. At the moment when I tried to call out to her that a meteor was descending close by, she leapt to her feet, screaming that she had been shot in the arm.

"I sprang up and ran to her, and on examining the arm we found a small red spot just above the elbow, which rapidly grew larger, and rose, a blister forming almost at once. It was exceedingly painful and had all the appearances of a fresh burn. The arm swelled, and the place made a quite painful sore. At present (four days later) it looks exactly like an old vaccination, being quite deeply pitted. On examining the dress, we found the sleeve scorched and burned through, in a tiny hole, just over the spot where the wound is. I send you a piece of the sleeve containing the burn. Unfortunately, the dress was washed before I thought of sending the piece to you, but the scorch is still plainly to be seen above the elbow."

Accompanying the letter was a bit of muslin cut from the sleeve on which the glowing fragment fell. The figure, resembling very closely the letter *y*, showed where the fabric is scorched entirely through. Unfortunately, in the excitement of the moment, and it being quite dark besides, no effort was made to find the meteorite.

The nearest dwelling, aside from that of the family, to the spot where Miss James was sitting at the time, is more than 200 yards away. There were no fireworks, rockets, etc., being sent up at the time, within miles and miles, and aside from the fact that Mrs. Roche saw the meteor from the time it entered the atmosphere until it struck, there is absolutely no room to doubt that the agent that made the burn was a traveler from the regions of ultramundane space.

A NEW TRADE ROUTE TO SIBERIA.

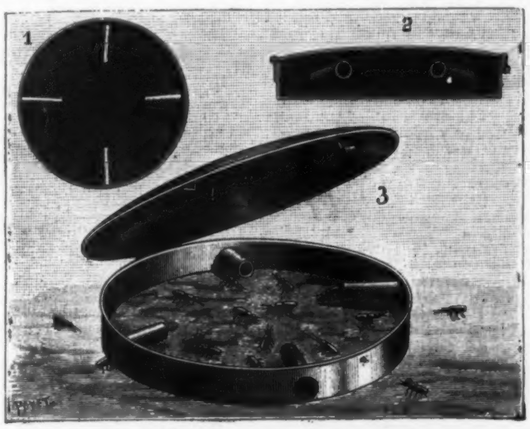
CONSIDERABLE interest is being taken in Siberia by the project for a new route to afford direct sea communication between Siberia and England. Though the new Siberian railway has done a great deal for the development of Siberia, it has hitherto shown itself quite unable to cope with a large traffic in bulky and in some degree perishable agricultural exports, owing to the deficiency in rolling stock. At present it frequently takes three or four months for Siberian wheat to reach the German markets. And even were this defect remedied, the cost of railway carriage over such very large distances as those of the Siberian railway must necessarily be very heavy. The only alternatives at present for Siberian exporters are to send their goods by railway via Perm to Kotlass on the Dwina, thence by river to Archangel, and from there by sea, or by water all the way down the Obi and through the Kara Sea. The latter route is very long and very uncertain, as both the Gulf of Obi and the Kara Sea are frequently ice-blocked in summer. The former rather combines the disadvantages of the long sea route and the long railway route. The scheme proposed by M. Gette, a Russian civil engineer, which meets with most favor, is for the construction of a railway from Obdorsk, near the head of the Gulf of Obi, across the northern end of the Urals to the open sea at Belkovsk Bay, south of Yugor Straits. Goods could come down to Obdorsk from the whole enormous basin of the Obi and be transshipped by this railway. The long sea route would thus be shortened by some 1,000 miles necessary to circumnavigate the Yalmal Peninsula, but the chief merit of the scheme lies in the fact that the open Arctic Ocean, west of Novaya Zemlya, is warmed by the last remnants of the Gulf Stream, and is therefore not so liable to be ice-blocked in the summer months as the Kara Sea and the Gulf of Obi. The Obi at Barnaul is free of ice for some 190 days a year, and at Obdorsk for 146, so that the whole route is open for practically five months in the year. M. Gette calculates that the freight from the wheat-growing districts of Siberia to England would be some 30 copecks a pood, roughly, 3s. per cwt., by the Obi-Obdorsk route, as against 53 copecks via Kotlass and Archangel, and 48 copecks through the Kara Sea. From the engineering point of view the line is said to present no very serious difficulties.—Commercial Intelligence.

A NOVEL TRAP FOR COCKROACHES.

MR. A. L. CLEMENT, in his recent study of cockroaches, speaks of means for destroying them, and cites the trap with small wings recommended by M. Chapelier. At the same time he adds that this trap can only be successfully used with the adults, since the weight of the larvæ is insufficient to move the wings. Herr Wilhelm Schultz, of Berlin, is of the same opinion. He says, also, that this trap possesses another disadvantage, namely, that the cockroaches, in order to enter it, must climb up its sides.

Herr Schultz has very kindly furnished us with a description of another still simpler little trap which he has used with success for nearly twenty years at Stuttgart. The illustration gives an idea of the general appearance of the trap and also shows its details.

As will be seen from the illustration, the trap consists of a round box made of zinc, with a convex cover and entrance holes level with the ground placed around the sides at equal distances. In these holes are placed small tubes, which are inclined upward slightly. No. 2 is a cross section of the box, showing two of the tubes; and No. 3 is a plan view of them. As the holes on the outside are level with the ground, the cockroaches enter them easily. The box should be filled with a little beer, preferably not fresh. The odor of this attracts them, and they pass through the tubes and fall into the beer, where they become drowsy. When the trap is full, the cover of the box is raised and hot water poured in, thus killing the insects.



A NOVEL TRAP FOR COCKROACHES.

This trap, besides being very simple and easy to construct, has the advantage of catching the young as well as the old, and will be found a useful article in almost every household.—La Nature.

PRESERVATIVES AND DYES IN ARTICLES OF FOOD.

ALONG with the fear of deleterious effects from the preservatives and coloring matters that are often added to certain articles designed to be taken into the human stomach, there is in most persons a natural antipathy to "doctored" products, as was shown by the recent outcry about "embalmed beef." And yet it seems that the community itself is in great measure to blame for the practice of adding to articles of food, beverages, preserves, pickles, confectionery, etc., substances intended either to preserve them or to give them an inviting appearance. At least, this appears to be the case in England, if we may judge from some of the testimony lately given before a committee of the Local Government Board as reported in The Lancet for November 25. For example, in the matter of ham and bacon from the United States and Canada it was contended by some of the witnesses representing the Liverpool Provision Trade Association that, if the preservation of such products rested on the use of salt alone, so much of it would have to be used that they would be too salt to suit the popular taste and, moreover, that they would be apt to get slimy; hence the prevalent practice of packing them in borax, which was wiped off when they reached England, not only was harmless, but insured a more acceptable food supply for the people. So, too, in the case of preserved fruit, jams, and the like, it was maintained that the public would not buy them unless they were of a desirable color; in particular, preserved white cherries were unsalable unless they were colored red. We do not think that this particular prejudice concerning the color of preserves prevails here in New York, but it must be admitted, we fear, that our people are set upon having their preserved peas and their pickles of a vivid green.

In spite of the strong statements of one physician as to the complete innocuousness of boric acid taken in daily amounts far in excess of those that would ever be taken into the stomach with preserved food, the medical testimony, so far as the hearing had proceeded, was almost unanimously in favor of prohibiting the use of preservatives, except sugar and salt, especially in milk to be taken by infants, although several of the witnesses were inclined to admit that their addition in not more than the required quantity would be harmless, except in the case of milk for children. A general feeling was evinced that all products to which chemicals had been added should bear a label informing the purchaser of such addition, but it was not generally insisted upon that the label should show the amount of preservative contained in the product; the New York and Pennsylvania requirement that the mere fact of chemical preservation should be stated seemed to be all that most of the witnesses would urge, and the trade representatives declared themselves quite ready to conform to such a regulation.

It may be unwise to decree the absolute prohibition of chemical preservation and coloring, but there can be no doubt that the use of chemicals and dyes ought to be regulated quite sharply. It was pointed out by some of the witnesses at this hearing that the preservative used was sometimes simply thrown into a mass of the food, and not properly mixed with it, whereas the desirability of its equable diffusion was too evident to be questioned. It was further suggested that a workman in a preserve factory, for instance, was apt to be careless about the ordinary precautions to be observed in the art of preserving if he knew that his shortcomings were to be rectified by the use of a chemical, and the result of his carelessness might be an inferior product quite independently of the fact of chemical preservation. These points seem to us well taken, and we have no hesitation in declaring that the employment of chemical preservatives and dyes should be regulated most stringently.—New York Medical Journal.

WHY IS THE NEGRO BLACK?

IN Pediatrics about a year ago a vehement discussion was raised by the publication in the editorial columns of that paper of the statement, made on the authority of a French physician, that negro babies when born were of a pinkish hue; in fact, differed little if at all in color from infants born of white parents. This expression of opinion was strongly rebutted by physicians in the South, who with unanimity declared that they had never seen a baby born of black parents white at birth. The Lancet in Great Britain took the matter up, as well as many medical journals on this side, and although their correspondents were all of one mind as to the negro progeny when born not being white, yet, curious to say, there was a considerable divergence of views with regard to the exact tint. The truth is, that all newly born negro infants are not of quite the same color, but vary to a certain extent. However, the assertion of the French physician that they are of a delicate pinkish hue was totally disproved.

Anthropologists and men of science have for long wrestled with the problem with respect to the cause of the color of the black man. Men of religion hold that it is owing to the curse of his father falling upon the descendants of Ham. Some think that the negro is a distinct race whose color has been the same since the world was first peopled, while again others contend that the human people were all originally of the same color, and that the change has been effected by the influence of the climate of the countries in which they have lived.

The question is dealt with in an interesting manner by a writer in a journal named The Family Doctor, who says: "Though children in tropical climates may be born apparently white, of parents whom the solar heat has darkened in hue, and though we have not the means of ascertaining that white nations exposed in tropical climates for ages do become darker, still, in conformity with the well-known law of the transmission of hereditary mental qualities, parents so blackened can communicate a slight though imperceptible tinge to their offspring, who will thus enter upon existence with a larger share of black than their parents, and if equally exposed themselves will convey more to the next generation. Thus the black tribes of Africa may have become so through a long succession of ages, while the more recently peopled countries of tropical America exhibit the process in a comparatively early stage. It is needless to present, in opposition to this theory, that no change has been observable since the discovery of America, for the ages required for the process must have been analogous to those required for geological phenomena, and are not to be squared

with our usual ideas of time. All the variations in the external appearance of man, however, cannot be referred to the influence of the solar heat, though, before mentioning other causes, we may point out another clear instance of its action. In the cases of the aborigines of Hindostan, who are somewhat browned in complexion, the action of the climate is clearly observable, which is proved by the circumstance of the female inhabitants of the harem, derived from the same stock, being generally fair in hue. This is unquestionably in consequence of their secluded life, which prevents that exposure of person which their relations of the other sex necessarily undergo. And, indeed, were color the only point to be considered, the doctrine of the action of climate might be held to be the best means of accounting for the wide varieties of the human species. . . . Whatever may be the immediate or remote causes of the dark complexion of the negro, philosophical inquiry has shown us that to him it is a provision of nature, mercy and benevolence. . . . The black color of natives of tropical regions may justly, then, be considered as a wise expedient provided by Omnipotence for cooling the fever of the blood under the influence of the scorching sun."

This theory is at least as plausible as any other, but taking the fact into consideration that the problem as to why the negro is black is impossible of definite solution, a discussion of the subject is, although interesting, perhaps somewhat useless.—Medical Record.

CAR LIGHTING WITH PINTSCH GAS, CITY GAS AND ACETYLENE MIXTURE.

THE idea of using cheap gas for car lighting, or of mixing acetylene with Pintsch gas to increase its richness, has long been an attractive one to railroad officers, and in response to a request from a well-known superintendent of motive power for information as to the possibilities of reducing the cost of car illumination, we have looked into the subject with a view of presenting the reasons why city gas and mixtures of Pintsch gas and acetylene are not used in this country.

Thirty-nine years ago the Philadelphia & Reading Railroad began to equip railroad passenger cars for lighting by gas. They built compressors and used city gas drawn from the mains in Philadelphia. Afterward a coal gas plant equipped with compressing, storage and delivery apparatus was established at Reading. The latter plant was changed into an oil gas plant, and the advantages of the richer gas, both in the economy of producing the required amount of light per hour, and the multiplied hours' supply, carried in the tanks of the cars, was so apparent that the use of city gas at Philadelphia was discontinued and a Pintsch plant established. The operation of the plant at Reading was then modified to conform with Pintsch practice as regards quality of gas and degree of compression.

The gas now used averages six times the value of compressed city gas. The latter is not manufactured for compressing, and suffers a considerable loss in illuminating power when compressed. Various tests show this to be from 40 per cent. to 60 per cent., the kind of gas, system of manufacture and method of operation all affecting the net result.

One hundred and sixty-seven cubic feet of Pintsch gas, the universal selling price of which is 85 cents throughout the United States, gives at least as much light as is given by 1,000 cubic feet of city gas, and to the first cost of the latter must be added the expenses incidental to its compression and delivery to cars. This additional cost averages about $1.25 per thousand cubic feet, making the net cost of 1,000 cubic feet of city gas in cars about $2.50. For a given amount of light, the less rich in illuminants the gas is, the more the cost of compressing enters into the cost of the light. Six times the cost of compressing must be included in the case of city gas, where the cost enters but once when Pintsch gas is used. Therefore the question arises, how rich a gas can be used and still further reduce this considerable element of cost?

The conditions of gas lighting on railroad cars are different from those generally met with in gas lighting, in this important respect: The entire apparatus is continually subject to jars and chatterings which detach dust, scale, etc., from the inner surfaces of pipes, tanks and fixtures. The detached particles are carried along by the flow of gas, and if any passage too small for them is encountered, a stoppage occurs. The smallest passage is usually the orifice of the burner, and in the early days of Pintsch practice in the United States, it was necessary to use a tip of the union jet type, having two holes each 0·023 inch diameter. Afterward a change was made to a larger size with holes 0·029 inch and a great improvement was effected. To reduce the size of these orifices below what are now used would therefore be a step in the wrong direction, but this would be necessary if a richer gas were supplied than is now furnished from the Pintsch plants. The question therefore of using a richer gas is disposed of by this practical limitation, and the question of the method of making the richest gas that can be used is one of dollars and cents.

The Pintsch gas supplied in the United States gives from 10 to 12 candles per cubic foot, varying according to the degree of compression and the temperature; either an increase of the former or a decrease of the latter tends to cause a reduction in candle power.

Acetylene mixed with Pintsch gas is used in Europe, and a great deal has been written on the subject. The practice there is to form a mixture 20 per cent. of which is acetylene and 80 per cent. Pintsch gas. By the addition of this proportion of acetylene the illuminating power of the gas is increased over 100 per cent., but even when so enriched it gives but 8½ candles per foot, the Pintsch gas in Europe being inferior in quality to the product of the American Pintsch gas. Experiments have shown that a mixture of 5 per cent. of acetylene with Pintsch gas made from American oils will combine to make a gas which has a tendency to smoke even when used in the small sized Pintsch tips.—American Engineer and Railroad Journal.

The present century has produced and consumed about 9,000,000 tons of copper, and a third of this amount has been used in the last ten years.

THE
Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers, 361 Broadway, New York.

TABLE OF CONTENTS.